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Valentin Crespy, Éric Benzenine, Anne Sophie Mariet, Anna Baudry, Chloé Bernard, et al.. Impact of the first COVID-19 pandemic peak and lockdown on the interventional management of carotid artery stenosis in France. *Journal of Vascular Surgery*, 2022, 75 (5), pp.1670-1678.e2. 10.1016/j.jvs.2021.11.064 . hal-03673613

HAL Id: hal-03673613

<https://hal.science/hal-03673613>

Submitted on 6 Jun 2023

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Impact of the first COVID-19 pandemic peak and lockdown on the interventional management of carotid artery stenosis in France

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ABSTRACT

Objective: The aim of this study was to evaluate the impact of the COVID-19 pandemic on the trends of carotid revascularization (endarterectomy [CEA], transfemoral carotid artery stenting [TFCAS]) for symptomatic and asymptomatic carotid stenosis before, during, and after the end of the first lockdown in 2020 in France.

Methods: Nationwide data were provided by the French National Hospital Discharge database (*Programme de Médicalisation des Systèmes d'Information*). We retrospectively analyzed patients admitted for CEA or TFCAS in all French public and private hospitals during a 9-month period (January-September) in 2017, 2018, 2019, and 2020. Procedures were identified using the French Common Classification of Medical Procedures. Stenoses were considered symptomatic in the presence of stroke and/or transient ischemic attack codes (according to the International Classification of Diseases-Tenth Revision) during the stay, and asymptomatic in the absence of these codes. Hospitalization rates in 2020 were compared with the rates in the same period in the 3 previous years.

Results: Between January and September 2020, 12,546 patients were hospitalized for carotid artery surgery (CEA and TFCAS) in France. Compared with the 3 previous years, there was a decrease in hospitalization rates for asymptomatic (−68.9%) and symptomatic (−12.6%) CEA procedures in April, starting at the pandemic peak concomitant with the first national lockdown. This decrease was significant for asymptomatic CEA ($P < .001$). After the lockdown, while CEA for asymptomatic stenosis returned to usual activity, CEA for symptomatic stenosis presented a significant rebound, up 18.52% in August compared with previous years. Lockdown also had consequences on TFCAS procedures, with fewer interventions for both asymptomatic (−60.53%) and symptomatic stenosis (−16.67%) in April.

Conclusions: This study demonstrates a severe decrease for all interventions during the first peak of the COVID-19 pandemic in France. However, the trends in the postlockdown period were different for the various procedures. These data can be used to anticipate future decisions and organization for cardiovascular care. (*J Vasc Surg* 2022;75:1670-8.)

Keywords: Coronavirus disease 2019; Pandemic peak; Carotid artery stenosis; Carotid endarterectomy; Carotid artery stenting; Lockdown

Since the beginning of the COVID-19 pandemic, there have been huge changes in medical and surgical care, particularly during the first lockdown in 2020. In practice, the lockdown was required to prevent viral transmission and to maintain the ability of health care centers to manage COVID-19 and non-COVID-19 emergencies.¹ Several reports have underlined a decrease in the rate of hospital admissions for medical emergencies such as

myocardial infarction²⁻⁵ or stroke,^{6,7} but the impact of the lockdown on the management of peripheral vascular diseases such as carotid stenosis still needs to be assessed. Carotid stenosis is considered to be responsible for 10% to 15% of ischemic strokes (IS).⁸ These strokes may be prevented by carotid endarterectomy (CEA) or transfemoral carotid artery stenting (TFCAS). In current guidelines, CEA for symptomatic stenosis must be

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Funded by the French National Research Agency.

Author conflict of interest: Y.B. received honoraria for lectures or consulting fees from BMS, Pfizer, Medtronic, Amgen, Servier, and Boehringer-Ingelheim, outside the submitted work. E.S. has conflicts of interest with Bayer, Biotronik and Cook Medical. The other author report no conflicts.

Additional material for this article may be found online at www.jvascsurg.org.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

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<https://doi.org/10.1016/j.jvs.2021.11.064>

performed within 14 days after symptom onset to decrease the risk of recurrent strokes and transient ischemic attacks (TIA), for which the risk in this period is up to 25%.⁹⁻¹¹ Assessing the repercussions of the COVID-19 pandemic on carotid revascularization, while differentiating CEA/TFCAS for asymptomatic and for symptomatic plaques, may help the national health care system to deal with such crises in the future.

The aim of this study was to evaluate the impact of the COVID-19 pandemic on the volume of CEA and TFCAS for symptomatic and asymptomatic carotid stenosis, observed before and during the first lockdown in 2020 in France. This analysis used complete nationwide administrative data from all primary and comprehensive hospitals, and compared the data from 2020 with the same time period in the 3 previous years. The second objective was to evaluate the volume of interventions for carotid stenosis in the 4 months after lockdown and to compare clinical characteristics between CEA and TFCAS patients.

METHODS

The nationwide data of this retrospective cohort study were provided by the French National Hospital Discharge database (*Programme de Médicalisation des Systèmes d'Information*, PMSI). This process was approved by the National Committee for Data Protection. Although confidential, PMSI data are available for researchers who meet specific criteria for access defined by the Agency for Information on Hospital Care (*Agence Technique de l'Information sur l'Hospitalisation*).

Hospitalization data. Hospitalization data from January to September 2017 to 2020 were extracted from the French National Discharge database, which collects the medical records of all patients discharged from all public and private hospitals in France. Hospitalizations included possible hospital transfers.

CEA and/or TFCAS were identified using the French Common Classification of Medical Procedures during the hospital stay. Because transcrotid artery revascularization is not yet available in France for the treatment of carotid stenosis, our study only refers to TFCAS.

Cerebrovascular events included IS and TIA. IS and TIA cases were identified according to the International Classification of Diseases-Tenth Revision codes recorded on the discharge abstract: the codes for IS were I63 and I64, and the code for TIA was G45. Stenoses were considered symptomatic in the presence of IS or TIA codes during the stay and asymptomatic in the absence of these codes. A sensitivity analysis was performed in which symptomatic stenosis was defined as the presence of an IS or TIA coded as the primary diagnosis on the first unit of the carotid revascularization intervention stay or coded in previous stays in the 60 days before the stay for carotid revascularization.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective cohort study of the French National Hospital Discharge database (*Programme de Médicalisation des Systèmes d'Information*)
- **Key Findings:** A 58% decrease in symptomatic and asymptomatic carotid stenosis surgeries was observed during the COVID-19 pandemic in France in April 2020 versus April 2017-2019, followed by a recovery toward prior levels, except for symptomatic carotid stenosis surgeries, for which there was a significant rebound exceeding the volume in prior years.
- **Take Home Message:** Hospitalizations and surgical interventions for symptomatic and asymptomatic carotid stenosis decreased during the peak of the COVID-19 pandemic, with no rebound after the first lockdown, except for symptomatic carotid stenosis interventions.

COVID-19 was identified using specific codes created by the Agency for Information on Hospital Care for this pandemic. The codes were considered as a primary diagnosis and as associated and secondary diagnoses. This ensured that the four diseases were identified even if another severe disease was the primary diagnosis.

Other variables were extracted: age in four classes (<65, 65-79, 80-84, and ≥85 years), sex, and available cerebrocardiovascular risk factors (hypertension, diabetes mellitus, obesity, atrial fibrillation), chronic renal failure, coronary artery disease, chronic obstructive pulmonary disease, chronic respiratory failure, and in-hospital death.

Study design. We retrospectively analyzed all patients admitted to primary or comprehensive public and private French hospitals for CEA and/or TFCAS between January 1 and September 30, 2020, and living in metropolitan France. This period included the first peak of the COVID-19 pandemic, the prelockdown period (weeks 1-11), the lockdown from March 17 (week 12) to May 10, 2020 (week 19), and the postlockdown period (weeks 20-40). Hospitalization numbers in 2020 were compared with the mean numbers from the same time periods in 2017 to 2019, month per month. Trends were represented for CEA/TFCAS overall and per type of procedure, for symptomatic and asymptomatic stenosis, and with the trends of all hospitalizations associated with COVID-19 (including CEA/TFCAS or not). Hospitalization trends for all IS or TIA were also reported (including CEA/TFCAS or not).

Clinical characteristics among the patients hospitalized for CEA and TFCAS were compared between two periods: during the lockdown in 2020 (ie, weeks 12-19) and the months of March, April, and May of 2017, 2018, and

2019, for the total population and then for symptomatic and asymptomatic stenosis subgroups.

This retrospective study had no impact on patient care and all data were anonymous. This study was authorized by the French Data Protection Authority on July 3, 2020 (Registration number: DR-2020-250 on 07/03/2020), and therefore was conducted in accordance with the Declaration of Helsinki. Written consent was not needed for this study.

Statistical analysis. Qualitative variables were presented as frequencies (percentages). Quantitative variables were presented as medians and interquartile ranges. The different variables analyzed in the cohort of hospitalized patients were compared using the χ^2 test or the Fisher exact test (for qualitative variables) and the median test (for quantitative variables) according to the two periods (weeks 12-19 in 2020 and March to May of 2017, 2018, and 2019). An interrupted time series analysis was performed to measure changes in hospitalization rates over time for each condition in January to September 2020, divided into the periods before, during, and after the lockdown. This model used weekly hospitalization rates over the study period and included a linear time trend. We thus quantified the impact of the lockdown as changes in the level and slope compared with the preceding period. The change in the number of stays for each disease in 2020 compared with the mean of 2017 to 2019 by month was plotted as smoothed curves using degree two spline functions. The statistical significance threshold was set at less than .05. All analyses were performed using SAS (SAS Institute Inc, Version 9.4, Cary, NC).

RESULTS

Between January and September 2020, 12,546 patients were hospitalized for carotid artery surgery (CEA and TFCAS) in France. This figure was 9.8% lower than the same period in the 3 previous years (2017-2019), during which a mean of 13,912 patients were recorded (Supplementary Table I, online only). In the 2020 national lockdown period (weeks 12-19), the decrease in the number of surgical interventions was parallel to the peak of the pandemic in France (Fig 1). This decrease started during week 9 (3 weeks before the beginning of lockdown) and continued until April, decreasing 58.4% compared with the mean of the previous years. A rebound occurred very quickly in April, and by June there was a complete recovery compared with prior years (Fig 1; Table I).

The same trends were observed in the total CEA group (Fig 2, A), and the asymptomatic CEA subgroup, which showed a 68.9% decrease in April 2020 (Fig 2, C; Table I). However, in the symptomatic CEA subgroup, there was a particular trend; after the initial decrease in interventions (-12.5% and -12.94% in March and April, respectively), there was a rapid increase in cases that

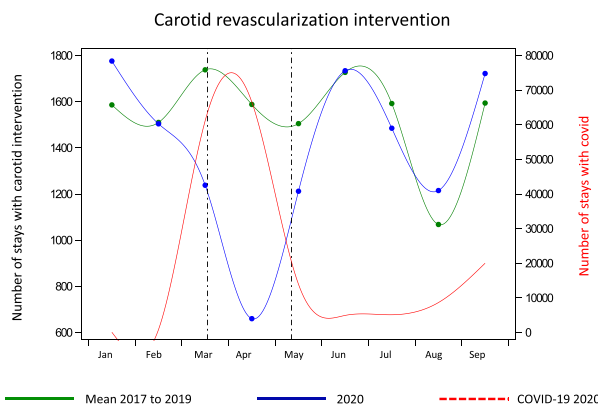


Fig 1. All carotid revascularization interventions in France in 2020 and in 2017-2019, and pandemic peak/number of hospitalizations.

started during lockdown and that went on to exceed the values of the previous years in the following months (18.5% more interventions in August and 10.03% more in September). After the end of lockdown, from May to September, CEA for symptomatic stenosis remained higher in 2020 compared with the same period in 2017 to 2019 (Fig 2, B; Table I).

Using interrupted time series for 2020, we observed a significant decrease in the level of CEA overall and for asymptomatic stenosis during lockdown compared with the period before lockdown, and there was a significant increase after lockdown compared with during lockdown ($P < .001$ for all) (Supplementary Fig, online only). For CEA for symptomatic stenosis, we observed a significant decreasing slope after lockdown ($P = .043$).

Similar trends emerged for all TFCAS procedures and for those performed for asymptomatic stenosis. In total, a mean of 903 TFCAS procedures were performed between 2017 and 2019, compared with 858 in 2020, totaling a decrease of 4.8% (Table I). There was a decrease in the volume of surgical interventions starting before lockdown in both the asymptomatic and symptomatic groups, followed by a fast recovery to usual activity levels during lockdown, and an increased number of procedures after lockdown when compared with previous years (Fig 3, B and C). The number of TFCAS for symptomatic stenosis was higher in 2020 than in 2017 to 2019 (Table I).

Using interrupted time series for 2020, we observed a significant decreasing slope for TFCAS for all patients and for asymptomatic stenosis before lockdown ($P = .030$ and $.024$, respectively), and a significant increase after lockdown compared with during ($P = .0094$ and $.015$, respectively) (Supplementary Fig, online only).

Hospitalizations for IS or TIA decreased during the lockdown and then returned to the usual numbers after the lockdown (Supplementary Table II, online only). The sensitivity analysis on the definition of symptomatic stenosis led to similar results.

Table I. Variation between monthly hospitalizations for carotid endarterectomy (CEA) and transfemoral carotid artery stenting (TFCAS) in France from January to September 2017 to 2019 (mean) and 2020

| Period | All variations (%) | Symptomatic stenosis | Asymptomatic stenosis |
|--|--------------------|----------------------|-----------------------|
| | | Variation (%) | Variation (%) |
| All carotid procedures (CEA and TFCAS) | | | |
| January | +10.67 | +1.50 | +12.38 |
| February | −0.40 | −0.74 | −0.32 |
| March | −28.77 | −12.50 | −32.06 |
| April | −58.44 | −12.94 | −68.41 |
| May | −19.47 | +8.82 | −26.04 |
| June | +0.40 | +6.77 | −0.90 |
| July | −6.72 | +1.69 | −8.61 |
| August | +12.10 | +18.52 | +10.02 |
| September | +7.43 | +10.03 | +6.91 |
| Total | −9.8 | +0.65 | −14.22 |
| CEA | | | |
| January | +10.46 | −1.24 | +12.51 |
| February | −1.62 | −0.82 | −1.71 |
| March | −28.16 | −10.37 | −31.71 |
| April | −58.98 | −12.60 | −68.90 |
| May | −18.03 | +9.76 | −24.56 |
| June | −0.25 | +7.47 | −1.78 |
| July | −6.39 | +1.48 | −8.15 |
| August | +9.03 | +18.25 | +6.16 |
| September | +7.52 | +8.78 | +7.35 |
| Total | −10.12 | +2.58 | −12.78 |
| TFCAS | | | |
| January | +14.75 | +25.93 | +11.56 |
| February | +15.18 | +4 | +19.54 |
| March | −37.5 | −24.62 | −37.65 |
| April | −50.50 | −16.67 | −60.53 |
| May | −38.61 | −5 | −46.91 |
| June | +8.53 | 0 | +11 |
| July | −11.43 | +4 | −16.05 |
| August | +43.93 | +21.74 | +50 |
| September | +6.19 | +22.22 | +1.16 |
| Total | −4.88 | +2.83 | −6.78 |

Boldface entries indicate the months concerned by the first lockdown in France.

The clinical characteristics of patients treated with CEA and TFCAS are presented in [Tables II](#) and [III](#), respectively. In-hospital death was similar in both groups. During the study period, 5 patients in the asymptomatic CEA group underwent surgery while suffering from COVID-19 (0.6%) compared with 12 patients in the symptomatic group (2.8%). Only one patient with COVID-19, who had symptomatic stenosis, underwent stenting treatment. In the TFCAS subgroups, there were no significant differences in age, sex, hypertension, diabetes, obesity, atrial fibrillation, chronic renal failure, coronary artery disease, chronic

obstructive pulmonary disease, or chronic respiratory failure. In 2020, there were more men in the CEA group overall (74.4% vs 71.5%; $P = .031$), less hypertension in the asymptomatic subgroup (54.7% vs 59.5%; $P = .0061$), and more diabetes in the symptomatic subgroup (31.5% vs 26.4%; $P = .028$). No significant differences were observed for the other available variables.

DISCUSSION

This nationwide population-based study revealed a deep drop in activity for overall carotid procedures

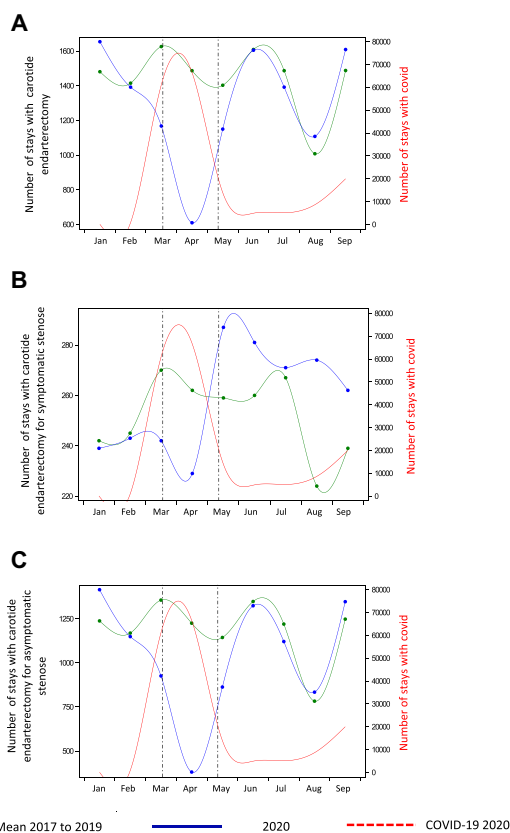


Fig 2. Monthly comparison of hospitalizations for carotid endarterectomy in 2020 compared with January to September 2017-2019. **A,** Carotid endarterectomy (CEA). **B,** CEA for symptomatic stenoses. **C,** CEA for asymptomatic stenoses.

(CEA + TFCAS) parallel with the peak of the first wave of the COVID-19 pandemic, which was not compensated for after lockdown. In the analyses focused on patients undergoing CEA, asymptomatic procedures showed the same trend. However, for symptomatic stenosis, the CEA numbers dropped around the peak of the first wave, but afterward we observed a rebound exceeding the usual activity in prior years. Moreover, patients who had a postponed CEA did not undergo TFCAS instead.

Earlier reports have described the local¹² or nationwide¹³ effects of COVID-19 and the lockdown in the vascular field. There are currently few available data to analyze how the pandemic has influenced carotid revascularization,^{3,13,14} and large ongoing international studies, such as the Covid-19 Vascular sERVICE (COVER) Study and the Vascular Surgery COVID-19 Collaborative (VASCC), are currently working on an assessment of the impact of the COVID-19 pandemic on vascular procedures.^{15,16} Nevertheless, several authors have emphasized the urgent need to quantify the pandemic's effects on surgical interventions and the practices of surgical teams.¹⁵⁻¹⁷

During the peak of the first wave, we observed a sharp decrease in CEA procedures for asymptomatic stenosis. This decrease has also been described in other studies, with decreases in usual activity ranging up to 90%.¹³ In France, this decrease in activity may have several explanations. CEA may have been postponed following the national public health strategy in the organization of the medical and surgical neurocardiovascular networks and owing to a shift in hospital priority toward medical and surgical COVID-19 emergencies. Some patients may have experienced a deterioration in preoperative health status and a higher mortality rate before the intervention, because carotid stenosis is most often diagnosed in elderly populations susceptible to severe infection and with a high risk of mortality.^{18,19} Asymptomatic patients may have been afraid of exposure to COVID-19 in the hospital, and public messages to stay at home to avoid COVID-19 contamination and to avoid overburdening the health care system may also have played a role in keeping patients at home. However, despite this clear decrease in cases, the overall number may seem high for an elective procedure during a pandemic. No national restrictions were imposed, and interventional strategies may have varied between centers, which may explain the remaining elective CEA activity in asymptomatic patients.

In symptomatic stenosis, the same decrease in CEA rates was observed in the month after the peak of the first wave. In France, we observed an initial phase of decline in the symptomatic population for several potential reasons, such as hospital adjustments to the pandemic (same as for asymptomatic stenosis) and limits on the number of procedures in some centers, as described in other countries,²⁰ contrasting with the increase observed by Pini et al in Italy.¹⁴ Moreover, CEA for symptomatic stenosis is performed for a minor stroke or TIA; a recent study demonstrated a decrease in stroke- or TIA-related hospitalization during the same period in France,⁶ suggesting that patients with minor symptoms made fewer visits to emergency units and stroke centers, perhaps resulting in an initial decrease in the number of procedures performed. Another explanation may be the decrease in air pollution, which is a trigger for the inflammatory reaction of vascular plaques.^{2,6} Finally, social isolation,⁶ patients dying at home, and misdiagnosis in emergency rooms are other factors that may be involved. The COVID-19 pandemic may also have led some institutions to implement radical changes in practice,^{13,20,21} and some interventions for symptomatic stenosis may have been delayed owing to organizational issues. In the subgroup of patients with symptomatic stenosis eligible for CEA, newly available data suggest that dual antiplatelet therapy should be introduced for patients with a recent TIA or minor stroke who cannot

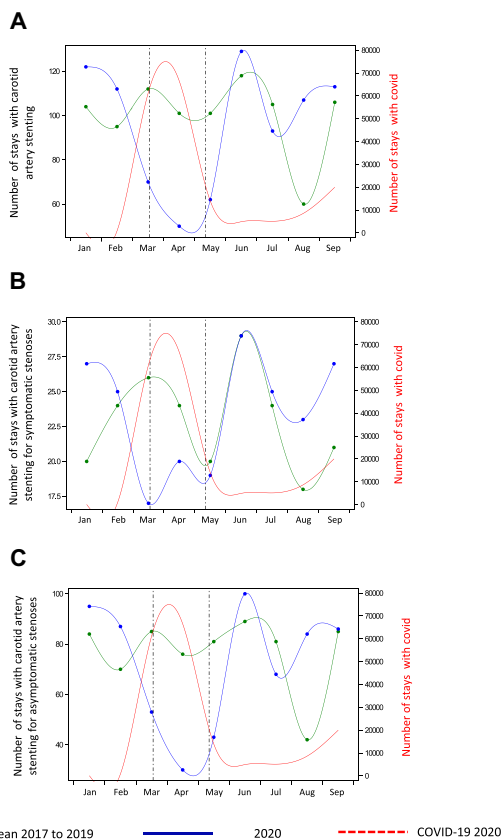


Fig 3. Monthly comparison of hospitalizations for carotid artery stenting in 2020 compared with January to September 2017-2019. **A,** Carotid artery stenting (CAS). **B,** CAS for symptomatic stenoses. **C,** CAS for asymptomatic stenoses.

be treated surgically^{20,22} to achieve maximum benefit and avoid recurrence.

In the postlockdown period, there was no visible compensation for the decrease in CEA performed in asymptomatic patients. It is possible that frail patients and those infected with COVID-19 were operated on at a later stage, possibly beyond the study period. Nevertheless, these data suggest that many patients with asymptomatic stenosis did not receive an early intervention in the weeks after the lockdown. In contrast, elective TFCAS interventions were maintained during the immediate postlockdown period. Afterward, we observed a decrease in TFCAS interventions during the summer, but the number was still higher than in previous years. For some patients, as suggested previously, TFCAS may have been offered instead of CEA so that local anesthesia could be used rather than cervical blockade or general anesthesia, which may have been unavailable.

An important finding of this work is the increase in the volume of symptomatic CEA procedures observed after lockdown. It is well-known that the risk of recurrent stroke is highest in the first 15 days after the index event. To limit the devastating effect of postponed CEA in

symptomatic patients, vascular surgery units may have implemented early measures to compensate for procedures that had been postponed. This effort may have been supported by adaptive strategies in the organization of medical and surgical neurocardiovascular networks, reinforcement from general practitioners, and improvements in public health education resulting from national campaigns focused on stroke and TIA over the last 10 years. Concerning TFCAS interventions in this particular pandemic period, one might have expected TFCAS to be preferred to over CEA if the intervention could not be postponed, for example, in patients with symptomatic stenosis. As mentioned elsewhere in this article, TFCAS can be performed under local anesthesia, without the need for an anesthesiologist and with a shorter hospital stay. Indeed, the latest European guidelines advise practitioners to consider carotid artery stenting as an alternative to CEA for some particular subgroups of patients at high risk for CEA, particularly for symptomatic stenosis.²³ The COVID-19 pandemic might have increased the number of patients considered to be at high risk for CEA and, therefore, increased the number of TFCAS interventions, as previously described.^{21,24} This was not confirmed herein, because the number of cases of TFCAS did not compensate for the CEAs that were not performed.

For clinical features, it is interesting to observe that patients with symptomatic carotid stenosis treated by CEA presented the classical vascular profile, including more males and more patients with diabetes, similar to the stroke population.⁶

The consequences of a postponed CEA or TFCAS for a population at risk of stroke with carotid stenosis might be serious, particularly in the symptomatic population, for whom the risk of recurrent stroke is higher in the first 15 days, potentially explaining the observed increase in interventions. For asymptomatic patients, recently updated data have shown a decrease in the spontaneous stroke risk of approximately 1% per year after improvements in medical treatments,²⁵ suggesting that these patients could be managed adequately without a carotid revascularization procedure. Although this issue remains to be clarified with ongoing trials, patients whose procedures are postponed should benefit from optimal medical treatment and be followed carefully. The low rate of complications in asymptomatic patients makes the effects of delayed procedures difficult to assess. For both symptomatic and asymptomatic stenosis, prospective stroke registries could be used to assess the consequences of postponing a carotid revascularization procedure. A detailed analysis of patient medical records will also be essential to measure the impact of the national lockdown over a longer period of time and the medical complications arising as a result. Regardless, it is important for vascular surgeons and stroke center teams to work closely together to improve patient screening and to provide CEA or TFCAS for symptomatic

Table II. Comparison of patient characteristics among carotid endarterectomy (CEA) groups between week 12 (mid-March) and week 19 (mid-May) 2020 as compared with March-April and May 2017-2019

| | Total | | | Asymptomatic | | | Symptomatic | | |
|-----------------------|------------------------|-------------------|-------------|------------------------|-------------------|--------------|------------------------|-------------------|-------------|
| | 2017-2019 ^a | 2020 (Week 12-19) | P Value | 2017-2019 ^a | 2020 (Week 12-19) | P Value | 2017-2019 ^a | 2020 (Week 12-19) | P Value |
| No. | 13,551 | 1271 | | 11,177 | 839 | | 2374 | 432 | |
| Male sex | 9689 (71.5) | 945 (74.4) | .031 | 7996 (71.5) | 620 (73.9) | .14 | 1693 (71.3) | 325 (75.2) | .096 |
| Median age, ears | 72.0 [13.0] | 73.0 [13.0] | .11 | 72.0 [13.0] | 72.0 [13.0] | .59 | 73.0 [16.0] | 74.0 [14.0] | .38 |
| Hypertension | 8260 (61.0) | 745 (58.6) | .10 | 6654 (59.5) | 459 (54.7) | .0061 | 1606 (67.7) | 286 (66.2) | .56 |
| Diabetes | 3471 (25.6) | 330 (26.0) | .79 | 2845 (25.5) | 194 (23.1) | .13 | 626 (26.4) | 136 (31.5) | .028 |
| Obesity | 1250 (9.2) | 135 (10.6) | .10 | 987 (8.8) | 74 (8.8) | .99 | 263 (11.1) | 61 (14.1) | .069 |
| Atrial fibrillation | 1284 (9.5) | 127 (10.0) | .55 | 946 (8.5) | 66 (7.9) | .55 | 338 (14.2) | 61 (14.1) | .95 |
| Chronic renal failure | 745 (5.5) | 68 (5.4) | .83 | 604 (5.4) | 37 (4.4) | .22 | 141 (5.9) | 31 (7.2) | .32 |
| Coronary disease | 3198 (23.6) | 282 (22.2) | .26 | 2706 (24.2) | 193 (23.0) | .43 | 492 (20.7) | 89 (20.6) | .95 |
| COPD | 969 (7.2) | 89 (7.0) | .84 | 836 (7.5) | 58 (6.9) | .55 | 133 (5.6) | 31 (7.2) | .20 |
| CRF | 126 (0.9) | 14 (1.1) | .55 | 100 (0.9) | 7 (0.8) | .86 | 26 (1.1) | 7 (1.6) | .35 |
| COVID-19 | 0 (0.0) | 17 (1.3) | NA | 0 (0.0) | 5 (0.6) | NA | 0 (0.0) | 12 (2.8) | NA |
| In-hospital death | 117 (0.9) | 9 (0.7) | .56 | 41 (0.4) | 2 (0.2) | .77 | 76 (3.2) | 7 (1.6) | .074 |

COPD, Chronic obstructive pulmonary disease; CRF, chronic respiratory failure; NA, not applicable.
The P value is for the χ^2 test or Fisher's exact test (for qualitative variables) or the median test (for age). Values are number (%) or median [interquartile range]. Boldface entries indicate statistical significance.
^aFor the following month: March-April and May 2017-2019.

Table III. Comparison of patient characteristics among transfemoral carotid artery stenting (TFCAS) groups between week 12 (mid-March) and week 19 (mid-May) 2020 as compared with March-April and May 2017-2019

| | Total | | | Asymptomatic | | | Symptomatic | | |
|-----------------------|------------------------|-------------------|---------|------------------------|-------------------|---------|------------------------|-------------------|---------|
| | 2017-2019 ^a | 2020 (Week 12-19) | P Value | 2017-2019 ^a | 2020 (Week 12-19) | P Value | 2017-2019 ^a | 2020 (Week 12-19) | P Value |
| No. | 944 | 82 | | 729 | 52 | | 215 | 30 | |
| Male sex | 655 (69.4) | 57 (69.5) | .98 | 504 (69.1) | 34 (65.4) | .57 | 151 (70.2) | 7 (23.3) | .47 |
| Median age, years | 71.0 [14.0] | 69.5 [15.0] | .071 | 71.0 [14.0] | 70.0 [16.0] | .31 | 70.0 [18.0] | 65.5 [15.0] | .30 |
| Hypertension | 513 (54.3) | 37 (45.1) | .11 | 383 (52.5) | 24 (46.2) | .37 | 130 (60.5) | 13 (43.3) | .075 |
| Diabetes | 204 (21.6) | 15 (18.3) | .48 | 157 (21.5) | 8 (15.4) | .29 | 47 (21.9) | 7 (23.3) | .86 |
| Obesity | 185 (19.6) | 14 (17.1) | .58 | 153 (21.0) | 10 (19.2) | .76 | 32 (14.9) | 4 (13.3) | 1 |
| Atrial fibrillation | 99 (10.5) | 4 (4.9) | .11 | 57 (7.8) | 2 (3.9) | .42 | 42 (19.5) | 2 (6.7) | .085 |
| Chronic Renal Failure | 62 (6.6) | 6 (7.3) | .79 | 48 (6.6) | 1 (1.9) | .24 | 14 (6.5) | 5 (16.7) | .066 |
| Coronary disease | 262 (27.8) | 15 (18.3) | .064 | 218 (29.9) | 11 (21.2) | .18 | 44 (20.5) | 4 (13.3) | .36 |
| COPD | 61 (6.5) | 4 (4.9) | .57 | 52 (7.1) | 3 (5.8) | 1 | 9 (4.2) | 1 (3.3) | 1 |
| CRF | 17 (1.8) | 1 (1.2) | 1 | 14 (1.9) | 0 (0.0) | .62 | 3 (1.4) | 1 (3.3) | .41 |
| COVID-19 | 0 (0.0) | 1 (1.2) | NA | 0 (0.0) | 0 (0.0) | NA | 0 (0.0) | 1 (3.3) | NA |
| In-hospital death | 24 (2.5) | 4 (4.9) | .27 | 3 (0.4) | 0 (0.0) | 1 | 21 (9.8) | 4 (13.3) | .52 |

COPD, Chronic obstructive pulmonary disease; CRF, chronic respiratory failure; NA, not applicable.
The P value is for the χ^2 test or Fisher's exact test (for qualitative variables) or the median test (for age). Values are number (%) or median [interquartile range].
^aFor the following month: March-April and May 2017-2019.

stenosis as quickly as possible. It is also important for vascular teams to closely follow patients with unoperated carotid stenosis who have been screened for CEA and TFCAS.

During a health crisis, there is a need to implement changes in the distribution of medical resources, and it is important to focus on the management of emergencies (such as symptomatic stenosis) and postpone elective

interventions (such as for asymptomatic stenosis). In the future, the experience provided by this first lockdown should allow us to quickly identify the interventions to be postponed and to organize the treatment and follow-up of unoperated asymptomatic patients.

Several limitations must be acknowledged. First, this study was retrospective and observational in nature. The time between the scheduling of a carotid intervention and its completion is not available in the PMSI, nor is information on whether the procedure was postponed. The definition of symptomatic and asymptomatic groups is debatable, because they were obtained in a national database, combining stroke with TIA and CEA with TFCAS in the same hospitalization. However, a sensitivity analysis where symptomatic stenosis was defined as the presence of an IS or TIA coded as the primary diagnosis on the first unit of the carotid intervention stay or coded in previous stays in 60 days before the carotid intervention stay led to similar results. Moreover, the identification of stroke and TIA in the PMSI by International Classification of Diseases-Tenth Revision codes was validated previously and this method has been used in published studies.²⁶⁻²⁸ Second, the results concerning TFCAS must be interpreted with caution because of the low number performed annually in France. Our study includes data for the 4 months after lockdown, but some of the consequences of the lockdown might not occur until later. The decrease in interventions highlights the importance of continuing regular monitoring of patients. Third, this methodology does not fully differentiate between preoperative stroke or TIA and perioperative or postoperative outcomes because the specific dates are not recorded for the occurrence of the condition or interventions during the stay.

The present study has several strengths. Although the collection of administrative data may be hindered by a delay in data collection, we have follow-up data collected through December 2020, reinforcing the reliability of the data collected in the 4 months after lockdown. All French primary and comprehensive public and private hospital data were included, and our data were thus nationally representative. In addition, although it has been well-documented in other countries that carotid stenosis procedures tended to decrease in the years preceding the COVID-19 pandemic,²⁹⁻³¹ our data from the pandemic period in 2020 are compared with the mean from the previous three years (2017-2019), also limiting the possible risk of a seasonal effect.

CONCLUSIONS

In this nationwide study, we report a 58% decrease in carotid revascularization procedures during the first lockdown in France, which was mostly owing to a decrease in procedures in asymptomatic patients. For symptomatic carotid stenosis interventions, we observed a rebound exceeding the volume in prior years. These data are of

major interest for the scientific community, because they can help to anticipate future challenges and needs in cardiovascular care, particularly in patients requiring carotid revascularization.

The authors acknowledge Suzanne Rankin for reviewing the English article and Gwenaëlle Periard for her help with the layout and management of this article.

AUTHOR CONTRIBUTIONS

Conception and design: VC, YB, MC, ES, CQ

Analysis and interpretation: ASM, AB, CB, CQ

Data collection: EB, ASM, CQ

Writing the article: VC, ASM

Critical revision of the article: VC, EB, ASM, AB, CB, YB, MC, ES, CQ

Final approval of the article: VC, EB, ASM, AB, CB, YB, MC, ES, CQ

Statistical analysis: Not applicable

Obtained funding: CQ

Overall responsibility: CQ

REFERENCES

1. Hartnett KP, Kite-Powell A, DeVies J, Coletta MA, Boehmer TK, Adjemian J, et al. Impact of the COVID-19 pandemic on emergency department visits - united States, January 1, 2019-May 30, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:699-704.
2. Mesnier J, Cottin Y, Coste P, Ferrari E, Schiele F, Lemesle G, et al. Hospital admissions for acute myocardial infarction before and after lockdown according to regional prevalence of COVID-19 and patient profile in France: a registry study. *Lancet Public Health* 2020;5:e536-42.
3. Ball S, Banerjee A, Berry C, Boyle JR, Bray B, Bradlow W, et al. Monitoring indirect impact of COVID-19 pandemic on services for cardiovascular diseases in the UK. *Heart* 2020;106:1890-7.
4. Mafham MM, Spata E, Goldacre R, Gair D, Curnow P, Bray M, et al. COVID-19 pandemic and admission rates for and management of acute coronary syndromes in England. *Lancet* 2020;396:381-9.
5. Bhatt AS, Moscone A, McElrath EE, Varshney AS, Claggett BL, Bhatt DL, et al. Fewer hospitalizations for acute cardiovascular conditions during the COVID-19 pandemic. *J Am Coll Cardiol* 2020;76:280-8.
6. Mariet A-S, Giroud M, Benzenine E, Cottenet J, Roussot A, Aho-Glélé LS, et al. Hospitalizations for stroke in France during the COVID-19 pandemic before, during, and after the national lockdown. *Stroke* 2021;52:1362-9.
7. Nogueira RC, Abdalkader M, Qureshi MM, Frankel MR, Mansour OY, Yamagami H, et al. Global impact of COVID-19 on stroke care. *Int J Stroke* 2021;16:573-84.
8. Petty GW, Brown RD, Whisnant JP, Sicks JD, O'Fallon WM, Wiebers DO. Ischemic stroke subtypes: a population-based study of incidence and risk factors. *Stroke* 1999;25:13-6.
9. Naylor AR, Rothwell PM, Bell PRF. Overview of the principal results and secondary analyses from the European and North American randomised trials of endarterectomy for symptomatic carotid stenosis. *Eur J Vasc Endovasc Surg* 2003;26:115-29.
10. Rothwell PM, Eliasziw M, Gutnikov SA, Warlow CP, Barnett HJM; Carotid Endarterectomy Trialists Collaboration. Endarterectomy for symptomatic carotid stenosis in relation to clinical subgroups and timing of surgery. *Lancet* 2004;363:915-24.
11. Naylor AR. Time is brain: an update. *Expert Rev Cardiovasc Ther* 2015;13:1111-26.
12. Hemingway JF, Singh N, Starnes BW. Emerging practice patterns in vascular surgery during the COVID-19 pandemic. *J Vasc Surg* 2020;72:396-402.
13. Mouawad NJ, Woo K, Malgor RD, Wohlauer MV. The impact of the COVID-19 pandemic on vascular surgery practice in the United States. *J Vasc Surg* 2021;73:772-9.

14. Pini R, Faggioli G, Vacirca A, Gallitto E, Mascoli C, Attard L, et al. Is it possible to maintain a regular vascular practice during the COVID-19 pandemic. *Eur J Vasc Endovasc Surg* 2020;60:127-34.
15. The Vascular and Endovascular Research Network (VERN) Committee. The COVID-19 Vascular sERvice (COVER) Study: an International Vascular and Endovascular Research Network (VERN) collaborative study assessing the provision, practice, and outcomes of vascular surgery during the COVID-19 pandemic. *Eur J Vasc Endovasc Surg* 2020;60:156-7.
16. D'Oria M, Mills JL Sr, Cohnert T, Oderich GS, Hultgren R, Lepidi S, et al. The "Vascular Surgery COVID-19 Collaborative" (VASCC). *Eur J Vasc Endovasc Surg* 2020;60:489-90.
17. Björck M, Boyle JR, Dick F. The need of research initiatives amidst and after the Covid-19 pandemic: a message from the Editors of the EJVES. *Eur J Vasc Endovasc Surg* 2020;59:695-6.
18. Banerjee A, Pasea L, Harris S, Gonzalez-Izquierdo A, Torralbo A, Shallcross L, et al. Estimating excess 1-year mortality associated with the COVID-19 pandemic according to underlying conditions and age: a population-based cohort study. *Lancet* 2020;395:1715-25.
19. Bellosto R, Piffaretti C, Bonardelli S, Castelli P, Chiesa R, Frigerio D, et al. Regional survey in Lombardy, Northern Italy, on vascular surgery intervention outcomes during the COVID-19 pandemic. *Eur J Vasc Endovasc Surg* 2021;61:688-97.
20. Naylor AR, McCabe DJH. New data and the Covid-19 pandemic mandate: a rethink of antiplatelet strategies in patients with TIA or minor stroke associated with atherosclerotic carotid stenosis. *Eur J Vasc Endovasc Surg* 2020;59:861-5.
21. Mangialardi ML, Orrico M, Mangialardi N. Routine in an Italian high-volume vascular surgery unit during the COVID-19 era: how the pandemic changed the vascular daily practice. *Ann Vasc Surg* 2020;66:6-7.
22. Prasad K, Siemieniuk R, Hao Q, Guyatt G, O'Donnell M, Lytwyn L, et al. Dual antiplatelet therapy with aspirin and clopidogrel for acute high risk transient ischaemic attack and minor ischaemic stroke: a clinical practice guideline. *BMJ* 2018;363:k5130.
23. Group W, Naylor AR, Ricco J, Borst GJ De, Debus S, Haro J De, et al. Management of atherosclerotic carotid and vertebral artery disease : 2017 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2018;55:3-81.
24. Hellegering J, van der Laan MJ, Heide E-Jde, Uyttenboogaart M, Zeebregts CJ, Bokkers RPH. Preventing stroke in symptomatic carotid artery disease during the COVID-19 pandemic. *J Vasc Surg* 2020;72:755-6.
25. Naylor AR. Time to rethink management strategies in asymptomatic carotid artery disease. *Nat Rev Cardiol* 2012;9:116-24.
26. Giroud M, Hommel M, Benzenine E, Fauconnier J, Béjot Y, Quantin C, et al. Positive predictive value of French hospitalization discharge codes for stroke and transient ischemic attack. *Eur Neurol* 2015;74:92-9.
27. Roussot A, Cottenet J, Gadreau M, Giroud M, Béjot Y, Quantin C. The use of national administrative data to describe the spatial distribution of in-hospital mortality following stroke in France, 2008-2011. *Int J Health Geogr* 2016;15:2.
28. Gabet A, Grave C, Chatignoux E, Tuppin P, Béjot Y, Olié V. Characteristics, management, and case-fatality of patients hospitalized for stroke with a diagnosis of COVID-19 in France. *Neuroepidemiology* 2021;55:323-30.
29. Lloyd-Jones D, Adams RJ, Brown TM, Carnethon M, Dai S, De Simone G, et al. Executive summary: heart disease and stroke statistics-2010 update: a report from the American Heart Association. *Circulation* 2010;121:46-215.
30. Hussain MA, Mamdani M, Tu JV, Saposnik G, Khoushhal Z, Aljabri B, et al. Impact of clinical trial results on the temporal trends of carotid endarterectomy and stenting from 2002 to 2014. *Stroke* 2016;47:2923-30.
31. Johal AS, Loftus IM, Boyle JR, Naylor AR, Waton S, Heikkila K, et al. Changing patterns of carotid endarterectomy between 2011 and 2017 in England. *Stroke* 2019;50:2461-8.

Submitted Jun 10, 2021; accepted Nov 12, 2021.

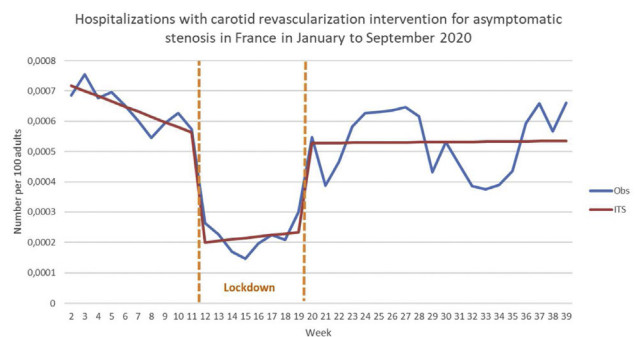
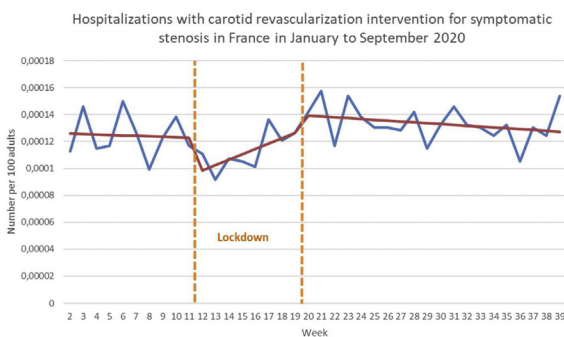
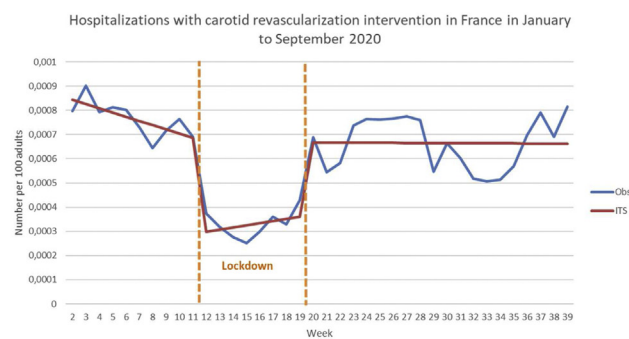
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Supplementary Table I (online only). Monthly hospitalizations for carotid endarterectomy (CEA) and transfemoral carotid artery stenting (TFCAS) in France from January to September 2017 to 2019 (mean) and 2020

| Period | All (a) | | Symptomatic stenosis (b) | | Asymptomatic stenosis (c) | |
|--|-----------|--------|--------------------------|------|---------------------------|--------|
| | 2017-2019 | 2020 | 2017-2019 | 2020 | 2017-2019 | 2020 |
| All carotid procedures (CEA and TFCAS) | | | | | | |
| January | 1590 | 1776 | 268 | 266 | 1321 | 1510 |
| February | 1510 | 1504 | 270 | 268 | 1240 | 1236 |
| March | 1738 | 1238 | 296 | 259 | 1441 | 979 |
| April | 1588 | 660 | 286 | 249 | 1301 | 411 |
| May | 1505 | 1212 | 279 | 306 | 1225 | 906 |
| June | 1727 | 1734 | 289 | 310 | 1437 | 1424 |
| July | 1592 | 1485 | 291 | 296 | 1301 | 1189 |
| August | 1068 | 1215 | 242 | 297 | 826 | 918 |
| September | 1594 | 1722 | 260 | 289 | 1334 | 1433 |
| Total | 13,912 | 12,546 | 2481 | 2540 | 11,426 | 10,006 |
| CEA | | | | | | |
| January | 1484 | 1654 | 247 | 239 | 1237 | 1415 |
| February | 1415 | 1392 | 245 | 243 | 1169 | 1149 |
| March | 1626 | 1168 | 270 | 242 | 1356 | 926 |
| April | 1487 | 610 | 262 | 229 | 1225 | 381 |
| May | 1403 | 1150 | 259 | 287 | 1144 | 863 |
| June | 1609 | 1605 | 260 | 281 | 1348 | 1324 |
| July | 1487 | 1392 | 267 | 271 | 1220 | 1121 |
| August | 1008 | 1108 | 224 | 274 | 783 | 834 |
| September | 1488 | 1609 | 239 | 262 | 1248 | 1347 |
| Total | 13,007 | 11,688 | 2273 | 2328 | 10,730 | 9360 |
| TFCAS | | | | | | |
| January | 105 | 122 | 21 | 27 | 84 | 95 |
| February | 95 | 112 | 24 | 25 | 70 | 87 |
| March | 112 | 70 | 26 | 17 | 85 | 53 |
| April | 101 | 50 | 24 | 20 | 76 | 30 |
| May | 101 | 62 | 20 | 19 | 81 | 43 |
| June | 118 | 129 | 29 | 29 | 89 | 100 |
| July | 105 | 93 | 24 | 25 | 81 | 68 |
| August | 60 | 107 | 18 | 23 | 42 | 84 |
| September | 106 | 113 | 21 | 27 | 85 | 86 |
| Total | 903 | 858 | 207 | 212 | 693 | 646 |
| Values are means. | | | | | | |

Supplementary Table II (online only). French nationwide monthly hospitalization numbers for ischemic stroke (IS) or transient ischemic attack (TIA) from January to September 2017 to 2019 compared with 2020

| Period | Before lockdown | | Lockdown | | After lockdown | | | | | Total |
|-----------------|-----------------|----------|----------|--------|----------------|--------|--------|--------|-----------|---------|
| | January | February | March | April | May | June | July | August | September | |
| 2017 | 14,352 | 13,426 | 15,561 | 13,206 | 14,275 | 14,245 | 13,188 | 13,440 | 13,360 | 125,053 |
| 2018 | 14,659 | 13,321 | 15,279 | 14,036 | 14,168 | 14,004 | 13,827 | 13,099 | 12,951 | 125,344 |
| 2019 | 14,876 | 13,343 | 14,773 | 14,013 | 14,403 | 13,455 | 13,655 | 12,780 | 13,423 | 124,721 |
| 2017-2019, mean | 14,629 | 13,363 | 15,204 | 13,751 | 14,282 | 13,901 | 13,556 | 13,106 | 13,244 | 125,036 |
| 2020 | 14,451 | 13,580 | 11,937 | 11,512 | 13,173 | 13,833 | 13,480 | 12,797 | 13,294 | 118,057 |



Supplementary Fig (online only). Observed (*Obs*) and predicted (*ITS*) hospitalizations for carotid revascularization intervention for weeks 2 to 39 of 2020 in France, interrupted time series (ITS) analysis with three periods (before, during, after the first lockdown).