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Non-ischemic neurovascular emergencies at a supra-regional medical center during the SARS-CoV2-pandemia

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ABSTRACT

Objective: To assess the impact of the lockdown in Germany due to the SARS-CoV2-pandemic on the incidence and the outcome of neurovascular emergencies at a tertiary medical center.

Methods: From March 16th, 2020 (first lockdown in Germany) to January 31st, 2021, all neurosurgical emergencies were included and compared to a longitudinal case-cohort. Cases were descriptively recorded and retrospectively analyzed with respect to incidence and outcome.

Results: All emergencies referred to our tertiary medical center decreased by 10% during the pandemic, whereas, neurosurgical emergencies increased by 18.4% (764 vs. 905 cases). Number of specific non-ischemic neurovascular emergencies increased by 29% (95 vs. 123 cases). The difference was not statistically significant (\( p = 0.53 \)). Mortality rate increased dramatically by 40% during the pandemic throughout all neurovascular cases. As all included patients were negative PCR-tested for SARS-CoV2 the observed increase is unrelated to the virus infection.

Conclusion: Unexpectedly, according to our data neurovascular emergencies raised in number and severity during the pandemic in Germany at our tertiary referral center. Furthermore, the case fatality increased. Even though our data lack proof of evidence for these findings, we might suggest two possible explanations for the absolute increase in numbers: firstly, patients might have refused to seek medical help while suffering only mild symptoms. Furthermore, as numerous lower-level medical centers restricted admissions, the referral times of patients in need of neurosurgical attention increased. We, therefore, suggest that even in a pandemic situation like the SARS-CoV2/COVID-19, it seems of utmost importance to retain dedicated neurovascular competence in designated centers to care for these emergencies.

1. Introduction

In December 2019, a new viral infectious disease, caused by the SARS-CoV2 (severe acute respiratory syndrome coronavirus type 2) causing the COVID19 (Corona Virus Disease 2019), was reported in Wuhan, China. The pathogen is a new beta-corona virus transmitting the human respiratory system. Among others, COVID19 might also affect the central nervous system as well as its vessels with an inflammatory response [1].

The pandemic took Germany approximately by February 2020. On March 16th, 2020, the first German lockdown was announced. In the wake of the lockdown, hospitals postponed all elective cases (if

Abbreviations: COVID-19, coronavirus disease 2019; SARS-CoV-2, severe acute respiratory syndrome coronavirus type 2; GSNR, German Society of Neuroradiology; GSN, German Society of Neurosurgery; DSG, German Stroke Society; TIAs, transient ischemic attacks; PCI, percutaneous coronary interventions; nSAH, non-traumatic subarachnoid hemorrhages; nICH, non-traumatic intracerebral hemorrhages source; AVM, symptomatic arterio-venous malformations; ICH, intracerebral hemorrhage; AVF, arterio-venous fistula; SDH, subdural hemorrhage; cSDH, chronic subdural hemorrhage; IVH, intraventricular hematocephalus; mRS, Modified Ranking Scale; ICU, Intensive care unit.

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COVID-19 patients in need of invasive ventilator therapy. Routine operations to provide sufficient intensive care unit (ICU) capacities for treating Germany [5,6].

...few percutaneous coronary interventions (PCI) were carried out in addition, the COVID-19 pandemic appears to have had a major impact on heart attack care in Europe, in numerous ways. As the results of the large multicenter ISACS-STEMI COVID-19 registry show, significantly fewer symptomatic cardiac emergencies were treated in Germany offering all medical specialties. As advised by the German Society of Neurosurgery (GSN), the German Society of Neuroradiology (GSNR) and the German Society of Neurosurgery (GSN).

The hospital is situated in an area with about seven million citizens representing nearly 10% of the 83 million German citizens (Destatis 2019). Furthermore, the hospital is a dedicated specialized clinic for neurovascular diseases, board certified by the German Stroke Association (GSA), the German Society of Neuroradiology (GSNR) and the German Society of Neurosurgery (GSN).

...have been instructed by the German government to provide sufficient intensive care unit (ICU) capacities for treating COVID-19 patients in need of ventila... and 18.4%.

Accordingly, the DSG reported a decline in hospitalization for acute ischemic stroke by 17.4% during the first couple of months of lockdown. Especially in patients suffering from mild symptoms (transient ischemic attack (TIA)), numbers fell to almost 23%, with severe strokes declining for about 17%. These figures are based on data from 1463 hospitals in Germany [5,6].

All third-level hospitals were instructed by the German government to provide sufficient intensive care unit (ICU) capacities for treating COVID-19 patients in need of invasive ventilator therapy. Routine operations were postponed (if possible) and admission to hospitals was restricted to emergencies. The medical professional societies released guidelines to define emergencies for each of their discipline [7]. Consequently, many patients kept away from seeking professional help as the lockdown continued and the incidence of SARS-CoV2 infections increased in Germany.

Because COVID-19 is a multi-system condition, we learned that SARS-CoV2 also affects the central nervous system, as well as its nurturing vessels with a mostly inflammatory response. However, little information is found how this affected the clinical practice in neurovascular centers in Germany [1].

Similar trends could be seen in our hospital concerning neurovascular emergencies. Our hospital is one of the largest in North Rhine-Westphalia and the fourth largest municipal maximum care hospital in Germany offering all medical specialties. As advised by the German societies of stroke, neuroradiology and neurosurgery, tertiary medical centers treating neurovascular diseases are certified as “Neurovascular Network Center” by the German TÜV (Technischer Überwachungsver...ein Deutschland), if they meet the criteria published before and serve as a regional referral center for adjacent (smaller) hospitals, that do not forhold all facilities to treat these conditions.

Our hospital has been certified as the coordinating center for such a neurovascular network, including 12 hospitals and rehabilitation facilities that all contribute to the standardized treatment of neurovascular emergencies as well as the elective cases. Therefore, the caseload of these has been considerably high at our center, even before the pandemic.

It is the aim of the current analysis to evaluate the impact of the SARS-CoV2 pandemic and the lockdown on non-ischemic neurovascular emergencies in a tertiary medical referral center in a non-university setting.

2. Methods

Our study is a retrospective, non-randomized, non-blinded and non-placebo-controlled data analysis of neurovascular cases at a tertiary medical center in Germany.

The hospital is situated in an area with about seven million citizens maintaining a rural region of about one million inhabitants. For this reason, even though the study reflects data of a single center, the results represent a cohort of the German citizen as the congested urban area reflects nearly 10% of the 83 million German citizens (Destatis 2019).
Diagnosis.

### Table 3
Patients with neurovascular emergencies.

|                         | period 1 (cohort-control group, March 16th, 2019 – January 31st, 2020) | period 2 (Corona pandemic, March 16th, 2020 – January 31st, 2021) |
|-------------------------|------------------------------------------------------------------------|------------------------------------------------------------------|
| female patients         | 63                                                                     | 83                                                               |
| male patients           | 32                                                                     | 40                                                               |
| duration total hospital stay (days) | 1370                                                               | 1365                                                             |
| duration in peripheral wards (days) | 441                                                               | 480                                                              |
| patients primary admitted at our hospital (n) | 31                                                                | 40                                                               |
| patients transferred from other hospitals (n) | 64                                                                | 83                                                               |

### Table 2
Comorbidities.

|                                | period 1 (cohort-control group, March 16th, 2019 – January 31st, 2020) | period 2 (Corona pandemic, March 16th, 2020 – January 31st, 2021) |
|--------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------|
| cardiovascular diseases        | 20                                                                     | 31                                                               |
| arterial hypertension          | 29                                                                     | 33                                                               |
| pulmonary diseases             | 4                                                                      | 2                                                                |
| cancer history                 | 2                                                                      | 9                                                                |
| combination of more than one system diseases | 35                                                                 | 25                                                               |

While ntSAH and nTICH decreased by 25% and 15.79%, respectively, during the lockdown, admissions due to symptomatic aneurysms, AVMs or SDH substantially rose in numbers. Yet, the increase in symptomatic aneurysms was statistically not significant ($\chi^2 = 0.77$).

Likewise, the incidences of cSDH and IVH were statistically not significant higher during the lockdown period ($\chi^2 = 0.91$).

The number of patients suffering from AVMs and AVFs, respectively, grew in number during the lockdown, too. Yet, due to the small overall number, we only provide descriptive results rather than statistical analysis. The diagnoses are described in Table 3.

We observed an increase of patients pretreated with anticoagulation medication (of various kinds) during the pandemic (Table 4). Still, this increase was within the normal distribution not reaching statistical significance.

The patients of the cohort in time period 2, during the lockdown, were of higher age, and also had a worse outcome with respect to the modified Rankin Scale (mRS). The number of fatal outcomes increased by 40%, though not reaching statistical significance ($p = 0.77$) (Fig. 1).

Nevertheless, the total increase of case-load was not caused by a raised incidence of severely afflicted patients, solely. Contrarily, we observed an increase of patients leaving the hospital in excellent condition (mRS0), too.

The individual duration of total hospital stay decreased by 3 days during the second period (14 days/patient, vs. 11 days/patient). The total days of hospitalization treatment did not differ significantly (1370 days vs. 1365 days).

### 4. Discussion

This is the first detailed long-term analysis on incidence and severity of non-ischemic neurovascular emergencies (N.I.N.E.) at a tertiary medical referral center during the pandemic and the following lockdown.

Ischemic strokes were not included for two reasons: firstly, a nationwide registry analysis revealed a decrease of strokes during the beginning phase of the pandemic [5,6]. Secondly the true number of ischemic strokes will not be sufficiently reflected by the admissions in the surgical emergency department of our tertiary medical center.

It was expected that number of these cases decreased similar to non-hemorrhagic stroke or heart attacks. This assumption was supported by the recent publication of Nguyen et al., who found a decrease of the event of subarachnoid hemorrhage in a global cohort over a three-months-period [8]. In contrast to their findings, we instead observed an increase in the incidence of N.I.N.E. in our cohort over a nine-months-period.

Numerous publications have consistently reported that the total number of admissions of patients to hospitals across the disciplines have markedly declined during the pandemic. Different hypotheses are discussed. First, the social distancing presumably led to reduced interaction of patients with family and friends, whereas early and mild symptoms might not be recognized. The view of these non-physicians is known to have an impact on the decision-making process to seek professional medical help, even though it may even delay treatment [9].

Second, patients avoided consulting their physician, because they were afraid of getting infected of SARS-CoV2. Concurrently, many physicians reduced direct contact to patients, often just in case of evident emergencies. Thus, emerging warning signs, red-flags indicating an uprising severe condition were most likely to be ignored. It has been reported that patients generally tend to see their practitioner before going to an emergency or outpatient department at a hospital [10]. Reduction of numbers of emergencies was therefore suspected.

The need for standardized requirements in the treatment of non-hemorrhagic stroke to warrant the best possible outcome for the patients has led to a nationwide certification process of stroke units [11]. In the follow, it became evident that the same requirements defined by personal and medical standards should be warranted for the treatment of neurovascular diseases at “neurovascular centers”. As the term “neurovascular center” was neither protected nor assigned to any pre-conditions the hospitals had to fulfill, it became evident that in analogy to the certification of stroke units a similar certification for the treatment of neurovascular cases was needed. In a joint venture of the German stroke society, the German association of neuroradiology and

### Table 4
Anticoagulation.

|                                | period 1 (cohort-control group, March 16th, 2019 – January 31st, 2020) | period 2 (Corona pandemic, March 16th, 2020 – January 31st, 2021) |
|--------------------------------|------------------------------------------------------------------------|------------------------------------------------------------------|
| acetylsalicylic acid (ASA)      | 16                                                                     | 20                                                               |
| antiplatelet medication         | 2                                                                      | 1                                                                |
| direct oral anticoagulants (DOAC) | 7                                                                     | 21                                                               |
| combination                    | 3                                                                      | 2                                                                |
| none                           | 67                                                                     | 79                                                               |
the German society of neurosurgery a consensus was filed, on whose base nowadays neurovascular networks with tertiary medical referral hospitals serving as coordinating centers are officially certified. This in turn has led to a successful certification process with 15 neurovascular networks being certified nationwide in Germany so far.

Interestingly, in our study non-ischemic neurovascular cases raised in number and severity during the pandemic-period in Germany. Furthermore, the case fatality increased. This may be explained by two circumstances during the lockdown. First, patients refused to seek medical help by their family physician while suffering only mild symptoms. Secondly, the referral times of patients in need of neurosurgical attention was much longer due to restricted admission at lower-level medical centers.

5. Conclusion

Even though, the incidence of N.I.N.E. did not raise statistically significant in our study database, the absolute numbers of occurring events rose at our third-level-center, requiring neurovascular competence even throughout unhandled exception situation like the first lockdown. However, the study showed that in both time-periods the intensive treatment of the patients with a neurovascular diagnosis maintains at the same high level. These results emphasize the importance for maximum care providers to generate sufficient and flexible capacities for non-COVID patients, as in the current study, for neurovascular diseases.

In addition, our data strengths the need to maintain a dedicated neurovascular competence in designated centers to care for these N.I.N.E. during a pandemic situation like the current SARS-CoV2.

CRediT authorship contribution statement

K Lintas – data collection, analysis and evaluation, drafting the manuscript. S Rohde - Head Dept. Radiology/Interv. Radiology, providing data on interventionally treated NINE, revising the manuscript. G Ellrichmann – Head Dept. Neurology, providing data from the neurological emergency and outpatient department, revising the manuscript. T. Strohmann – Head Emergency Room/trauma center, providing data from the trauma registry, revising the manuscript. B El Hamalawi – senior consultant neurosurgeon, Section vascular neurosurgery, providing data on NINE surgically treated, revising the manuscript. R Sarge – senior consultant neurosurgeon, ICU neurosurgery, providing data on the intensive care of NINE patients, revising the manuscript. O Müller - Head Dept. Neurosurgery, drafting the study, ethic committee approval, data evaluation, final revision of the manuscript. The current study has been an interdisciplinary effort of the management of patients suffering N.I.N.E.; even though the number of authors might appear rather high at a first glance, we would appreciate, if all concerned colleagues will be fully considered.

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