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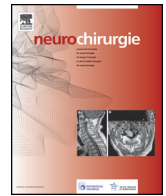


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Original article

Investigating the real impact of COVID-19 pandemic on the daily neurosurgical practice?



Quel impact de la pandémie à SARS-CoV-2 sur les soins neurochirurgicaux ?

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ABSTRACT

Objective. – The objective of this study was to relate the neurosurgical activity during a time of sanitary crisis such as experienced during the SARS-CoV-2 pandemic.

Methods. – A monocentric retrospective analysis was made based on a prospectively gathered cohort of all patients requiring neurosurgical care between March 15th and May 12th, 2020. Local impact of SARS-CoV-2 was analysed regarding number of patients admitted in ICU.

Results. – One hundred and sixty patients could benefit from neurosurgical care with a wide-ranging profile of clinical and surgical activities performed during the study that seemed similar to last year profile activity. Surgical indications were restricted to non-deferrable surgeries, leading to a drop in operative volume of 50%. Only 1.3% of patients required transfer to other units due to the impossibility of providing gold standard neurosurgical care in our centre.

Conclusion. – Despite the challenges represented by the SARS-CoV-2 pandemic, it was proven possible to ensure the routine neurosurgical continuity and provide high standards of neurosurgical care without compromising patients' access to the required treatments.

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1. Abbreviations

| | |
|------|---|
| CSF | cerebrospinal fluid |
| EPR | electronic patients records |
| GCS | Glasgow Coma Scale |
| ICU | intensive care unit |
| KPS | Karnofsky Performance Status |
| SAH | subarachnoid hemorrhage |
| WFNS | World Federation of Neurosurgical Societies |

2. Introduction

COVID-19 global pandemic, triggered by the rapid diffusion of SARS-CoV-2 in the first months of 2020, is assuming month after

month the dimensions of the worst outbreak recorded in modern medicine [1]. This entails processes of triaging, prioritisation and rationing of available resources [2]. From a neurosurgical perspective, the high virulence of SARS-CoV-2 and the severe natural course of COVID-19 eroded the availability of high dependency and intensive care units (ICU) beds, practically shutting down elective neurosurgical services [3–5].

Recommendations, guidelines and checklist had been rapidly developed and implemented throughout the world [6–10]. The number of cases recorded in the Northeastern part of France was particularly high, putting Alsace among the epicentres of the pandemic in the country. Comparing to other surgical fields, the decision-making process in neurosurgery has to be driven by considerations for patients rapidly decompensating due to raised intracranial pressure or evolving neurological deficits. Such approach to neurosurgical pathologies is well summarised by the motto “Time is brain”, implying how difficult and unethical could be to delay or postpone interventions condemning patients to dismal outcomes [11–13].

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The epidemiological relevance of this study resides in the possibility of quantifying the unprecedented impact of the COVID-19 pandemic in the Northeastern part of France through the assessment of the performance of our department, which offers management for the complete spectrum of neurosurgical pathologies.

3. Patients and methods

3.1. Study design

A single centre prospective registry allowed the gathering of data on an observational longitudinal cohort of 160 patients managed at Strasbourg University Hospital during a 2 months period starting from March 15th–May 12th, 2020. Some data could be confronted to historical clinical data collected from our electronic patients records (EPR) for the same period of the year 2019.

3.2. Ethics

This study was conducted according to the Ethical Principles for Medical Research Involving Human subjects stated in the 2004 and its further revision made in 2008 and 2013 of the Declaration of Helsinki. Ethical approval and clinical trial registration were obtained by the local IRB (study number: CE-2020-71, April 30th, 2020) and discussed with our COVID-19 Ethical Committee. The reporting of the study has been planned and conducted in adherence to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for observational studies and checklist [14].

3.3. Objectives

The aim of this study was to obtain a snapshot of neurosurgical activity in Strasbourg concomitant to the maximal impact of the first wave of COVID-19 pandemic. This was achieved through our primary objective: illustrating the “daily neurosurgical activity” performed in the months March–May through a descriptive analysis of our prospective database. The secondary objective was to appraise the performance under COVID-19 with that under routine circumstances (non-restrained surgical activity).

To fulfil both objectives the performance of our department was assessed with regards to number of available ICU beds and ventilating machines. Those aspects are in fact thought to be the main criteria to measure the severity of the pandemic. Furthermore, both objectives entailed a precise assessment of the key pathologies and related surgical procedure performed, their degree of urgency, and surgical outcome. To this regard, the main points of interests were mechanism of traumatic injuries, oncologic profile/management of malignant tumours, and characteristics of subarachnoid haemorrhage.

3.4. Standard local set-up organisation

Our neurosurgical unit includes 38 conventional beds, and 6 high dependency care unit (HDU) beds. The mean number of operation per/year is about 1600 for a catching population of about 1,100,000 people including all neurosurgical domains as functional, vascular, neuro-oncology, hydrocephalus, degenerative spine, brain and spine trauma, paediatric and epilepsy surgery. The number of ICU beds is 90, the average bed occupancy rate is 85%.

3.5. Local epidemic context

South-Alsace (Haut-Rhin department) was a particularly relevant cluster of COVID-19 patients since mid February 2020.

North-Alsace (Bas-Rhin department) followed on the same path of diffuse spreading with a delay of only one week. At the peak of the outbreak (March–May 2020) COVID-19 positive patients in critical medical conditions had to be transferred from Strasbourg to other French hospitals and even abroad due to saturation of internal resources. From March 17th to May 11th a national state of sanitary confinement was declared.

4. Patients and methods

All patients admitted to our neurosurgical department during the SARS-CoV-2 pandemic period as well as all neurosurgical referrals and external consultations were included in a prospective registry, which ran from March 15th to May 12th 2020. The registry included every adult requiring neurosurgical care at our institution, either in our unit or under our supervision in other units. Paediatric patients admitted in the local department of paediatric surgery were excluded from this study.

The following data were collected and reviewed for each patient: demographic characteristics (anonymised identification hospital number, date of birth, gender), reason for admission, clinical symptoms, COVID-19 status, surgical procedure (if performed) and its degree of urgency (see also Table 1). Priority criteria for surgeries were defined according to a previously described grading system [7], triaging consisted in the identification of: emergency (EM group) patients, requiring immediate surgical treatment (within hours), deferrable (UP group) patients, requiring treatment within a maximum of 7–15 days and elective (EL group) patients, requiring treatment within two months. The positive COVID-19 status was defined as follows: positive SARS-Cov-2 PCR on nasopharyngeal swab and/or typical radiographic lesions on a chest CT-scan [15].

4.1. Endpoints

In order to evaluate the severity of the pandemic and COVID-related adjustments made during this period of time, the followings were studied: numbers of COVID-19 positive patients admitted to ICU for mechanical ventilation, COVID-19 positive patients requiring neurosurgical care, COVID-19 positive patients transferred to other hospitals and the number of patients transferred to another medical centre due to impossibility of providing gold standard surgical management. Neurosurgical care was defined as either the performance of a surgical procedure by a neurosurgeon or a medical attention and conservative treatment in a neurosurgical unit.

Patients were classified according to the following categories: traumatic, neurovascular, infectious, neuro-oncology, hydrocephalus, degenerative spine, and functional neurosurgery. Relevant parameters specific to the different pathologies treated were noted: trauma mechanism, if any addiction present (alcohol, drugs, etc.) and Glasgow Coma Scale (GCS) for traumas, World Federation of Neurosurgical Societies (WFNS) score for subarachnoid haemorrhage, Karnofsky Prognostic Scale (KPS) and therapeutic strategy (biopsy/surgical removal) for neuro-oncology. These endpoints could be confronted to similar data available regarding last year.

4.2. Statistical analysis

Variables were classified as continuous or categorical. Mean, ranges, and medians were used for continuous data collected in the study. Categorical data were presented as total count and proportions. Fisher exact test was done within the studied variable. A P -value < 0.05 was considered statistically significant. Graphpad

Table 1
Neurosurgical care during the lock down by pathologies.

| Patients | Surgical cases (EM/UP/EL) | Non-surgical cases | Total |
|--|---------------------------|--------------------|------------|
| Trauma | 23 [6/15/2] | 25 | 48 (30.0%) |
| Chronic subdural haematoma | 14 [3/9/2] | – | 14 |
| Head trauma alone | 5 [3/2/–] | 17 | 22 |
| Craniovertebral trauma | 1 [–/1/–] | 2 | 3 |
| Spine trauma alone | 3 [–/3/–] | 6 | 9 |
| Neuro-oncology | 27 [7/15/5] | 16 | 43 (26.9%) |
| Metastasis | 12 [5/7/–] | 7 | 19 |
| Glioblastoma | 7 [1/4/2] | 5 | 12 |
| Meningioma | 1 [–/1/–] | 3 | 4 |
| Lymphoma | 2 [–/2/–] | – | 2 |
| Ependymoma | 1 [–/–/1] | – | 1 |
| Craniopharyngioma | 1 [–/–/1] | – | 1 |
| Pituitary adenoma | 1 [1/–/–] | 1 | 2 |
| Ethmoidal adenocarcinoma | 1 [1/–/–] | – | 1 |
| PNET | 1 [–/1/–] | – | 1 |
| Degenerative spinal disease | 18 [1/8/9] | 7 | 25 (15.6%) |
| Cervicarthrosic myelopathy | 6 [–/1/5] | – | 6 |
| Cervico-brachial neuralgia | 1 [–/–/1] | – | 1 |
| Hyperalgetic sciatalgia | 9 [1/6/2] | 7 | 16 |
| Herniated lumbar disc with motor deficit | 1 [–/1/–] | – | 1 |
| Lumbar stenosis | 1 [–/–/1] | – | 1 |
| Neurovascular | 8 [6/2/0] | 12 | 20 (12.5%) |
| Aneurismal subarachnoid haemorrhage | 4 [4/–/–] | 1 | 5 |
| Non-aneurismal subarachnoid haemorrhage | 1 [1/–/–] | 5 | 6 |
| Spontaneous intracerebral haemorrhage | 2 [1/1/–] | 1 | 3 |
| Cavernoma | 1 [–/1/–] | 3 | 4 |
| Malignant sylvian ischaemic stroke | – | 1 | 1 |
| Spontaneous epidural cervical haematoma | – | 1 | 1 |
| Infection | 8 [4/3/1] | 2 | 10 (6.3%) |
| Foreign material infections | 4 [1/2/1] | – | 4 |
| Cerebral abscess | 2 [2/–/–] | – | 2 |
| Cerebral opportunist infection | 1 [–/1/–] | – | 1 |
| Meningo-encephalitis | – | 1 | 1 |
| Scar reopening | – | 1 | 1 |
| Infectious discitis with epidural collection | 1 [1/–/–] | – | 1 |
| Functional | 5 [0/2/3] | 4 | 9 (5.6%) |
| Hydrocephalus (acute shunt dysfunction) | 4 [3/1/0] | 1 | 5 (3.1%) |
| Neurosurgical care | 93 (58.1%) [27/46/20] | 67 (41.9%) | 160 |

EM: emergency; UP: deferrable; EL: elective.

The degrees of emergency for requiring surgical treatment were immediate (within hours) for EM, within a maximum of 7–15 days for UP and within two months for EL.

online calculator was used for all statistical analysis of the study (<http://www.graphpad.com/quickcalcs/>).

5. Results

5.1. Local impact of SARS-Cov2 pandemic

The severity of the local epidemic context related to SARS-CoV-2 infection is summarised in Fig. 1. The average ICU beds capacity exceeded 163% during 57 consecutive days at our institution, with a peak of 213% reached on April, 2nd. The mean ratio between COVID-19 positive patients and those with any other pathology requiring mechanical ventilation was 5/1, with a peak of 20/1. Moreover, 56 COVID-19 positive patients were transferred from Strasbourg hospital to others regional hospitals (included abroad in Germany and Switzerland) during the period of interest (62 days).

5.2. Neurosurgical care during lock down

A total of 160 patients received neurosurgical care, 93 (58.1%) of them underwent at least one surgical procedure (see also Table 1). Among surgical patients, the degree of urgency was as follows: 27 EM patients (29.0% of surgical group), 46 UP (49.5%) and 20 EL patients, representing 29%, 49.5% and 21.5% of surgical group, respectively. Among those included in the surgical group, 7 patients (7.5%) underwent several interventions, bringing the total number of neurosurgical procedures performed to 101.

Out of the total number of 160 patients admitted, only 2 patients (1.3%) had to be transferred to another neurosurgical centre (a brain metastasis from melanoma requiring awake surgery, and a lumbar herniated disc causing cauda equina syndrome). Only 13 COVID-19 positive patients (8.12%) were detected on admission to the ward. Additionally, 2 patients with an initially negative COVID-19 swab tested positive during their inpatient stay: status conversion occurred after 22-days and 8-days, respectively.

In 2019 during the same period, 202 patients underwent at least one surgical procedure, for a total of 214 surgeries (see Fig. 2) versus 101 surgeries performed in 2020; indicating a drop in operative volume of more than 50%. However, the case mix remains very similar between the two periods, with the exception of functional procedures, which have been postponed by default during the lockdown period.

5.3. Relevant pathologies impacted

Among the 25 TBI cases only one was severe (initial GCS 8). Of note, the mechanism of injury for all traumas was a low speed impact in most of the cases. Additionally, excessive alcohol consumption was a leading cause of injury (13 cases). All chronic subdural haematomas were surgically evacuated (14 cases), with a favourable outcome in 13 of them (92.9%), defined as a GCS 15 at 6 weeks follow-up post-surgery. A limited number of patients had other chronic conditions (5 cases), such as diabetic polyneuropathy, Parkinson disease, and Alzheimer disease.

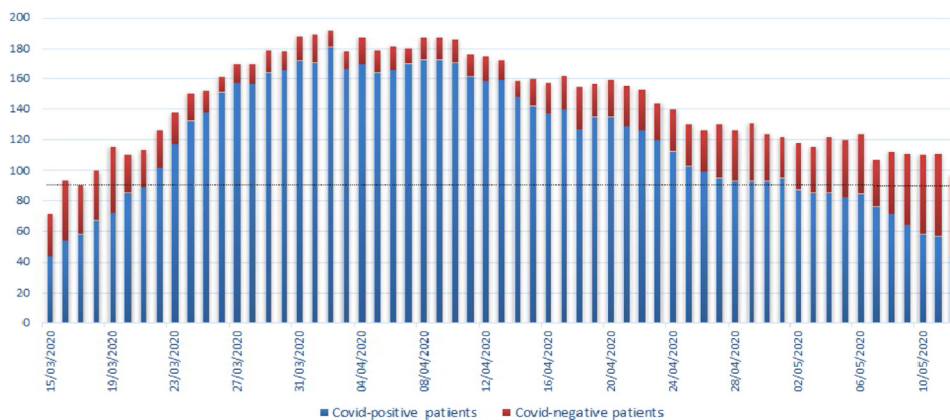


Fig. 1. Number of patients admitted in intensive care unit (ICU) each day from March 15th to May 12th, 2020. Patients were classified according to their COVID-positive (blue) or COVID-negative (red) status. The dotted line represents the usual ICU capacity of our institution (90 beds).

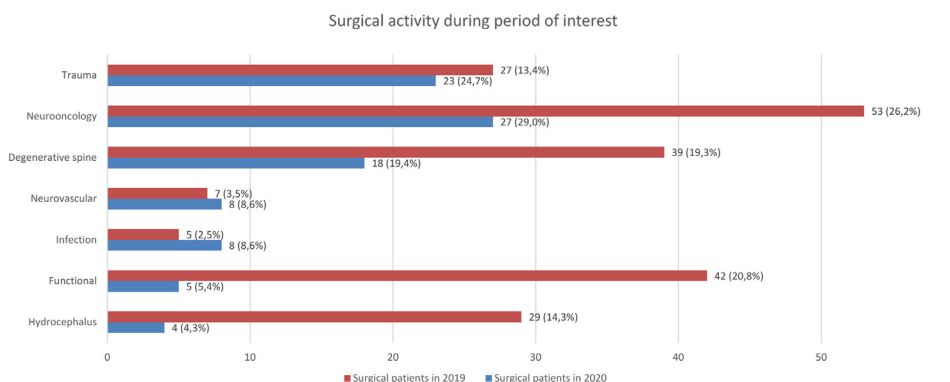


Fig. 2. Direct comparison of neurosurgical activity performed during the 2 different period: 2020 (lock down) and 2019 by pathologies, number of patients and their proportion. Patients from 2020 are represented by blue bars, patients from 2019 by red bars.

All patients with glioblastomas underwent stereotactic biopsy (for a total of 7 cases) as a surgical removal was not indicated due to their multifocal extension or deteriorated general condition at diagnostic. In comparison, only 3 (30%) patients had undergone a biopsy alone in 2019 out of 10 surgically managed glioblastomas. This difference between 2019 and 2020 was statistically significant (P -value < 0.011).

Only 3 patients harbouring benign intracranial lesions were admitted due to acute onset of clinical signs of intracranial hypertension and/or visual disturbances.

During the study period only 1 patient required endoscopic endonasal procedure for pituitary apoplexy with abrupt loss of visual acuity. This case was carried out with careful adoption of all the precautions previously described by skull base surgery societies [16,17].

Among the 5 patients admitted for an aSAH, one presenting with poor clinical conditions (WFNS 5) died rapidly after the admission. The others (3 patients presenting as WFNS 1, and 1 presenting as WFNS 2) were managed by surgical clipping (2 cases) or endovascular treatment (2 cases). In comparison, during the period March 15th–May 12th, 2019 only 3 cases of aSAH required treatment.

6. Discussion

The overflow of patients needing ICU care during such unprecedented healthcare crisis reflects the diffusion and severity of SARS-CoV-2 infection in our region. In this context, the detailed analysis of the clinical activity of our neurosurgical department demonstrated that it was possible, although quite challenging, to ensure a continuity of care. This conclusion can be drawn based

on two key performance measures. First, the very low proportion (1.3%) of patients transferred elsewhere to receive the neurosurgical care they needed. Second, the wide and rich case mix characterised by a range and profile of activities consistent with our usual standards. Thus, despite restrictions in our material and human resources, continuity and quality of neurosurgical care have never been compromised.

Surgical strategies were modified to treat only patient with non-deferrable indications, after discussion with an “ad hoc” created institutional Ethics Board [9]. The creation of a dedicated SARS-CoV-2 Ethics Board played in fact a crucial role in guiding and supporting all practitioners during their clinical decision-making. We believe that the constant discussion with our COVID-19 Ethics Board helped us greatly in always respecting the patients and their dignity, while keeping a holistic medical approach.

No programmed surgery could be done during the lockdown period, moreover the use of surgical implants was limited to lifesaving procedures, therefore, it is easy to understand why all functional neurosurgery interventions have been postponed, with the exception of replacing neurostimulator batteries. Surgical facilities could be made available only for neurosurgical emergencies and non-deferrable cases. Despite that, the surgical activity remained very diversified. The drop recorded in terms of operative volumes, as well as the adaptation strategy depicted here seem to be consistent with data found in the literature [12].

The decrease of high-speed head traumas was linked with national restriction of individual mobility. This allowed sustaining the overflow of patients in ICU and HDU, where 97% of mechanically ventilated patients were COVID-19 positive patients. Among malignant lesions, the glioblastomas treated during the lockdown

appeared to be more aggressive than usual, in fact simple diagnostic biopsy resulted to be the management strategy of choice. Though the incidence of aSAH during the COVID-19 pandemic remains controversial in the literature, it was not reduced in this study [18,19].

The main limitation of this study resided in its retrospective monocentric design. The method of data collection used in this study differed from available registries regarding year 2019 (prospective cohort including every patient whether undergoing surgery or not versus retrospective electronic record of surgeries). Thus, no real statistical comparison could be made. Only tendencies could be suggested by the confrontation of these registries. Moreover, the brief inclusion procedure took end on May 12th, no data being available regarding the post-confinement period. Thus, the hypothesis of a “rebound effect” in underrepresented pathologies during the confinement period could not be studied.

7. Conclusion

This study demonstrated that a prompt re-organization of the neurosurgical department in Strasbourg, thoughtfully implemented in the early stages of the first wave of the COVID-19 pandemic allowed a wide-range of surgical procedures to be performed safely, timely and effectively. While the routine practice was disrupted with a drop in surgical volume of about 50%, the case mix documented in this report suggests that through careful organizational planning, clinical triaging and prioritization we were able to manage pathologies from the entire neurosurgical spectrum despite the constraints imposed by this healthcare crisis.

Human and animal rights

The authors declare that the work described has not involved experimentation on humans or animals.

Informed consent and patient details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s) and/or volunteers.

Disclosure of interest

The authors declare that they have no competing interest.

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Author contributions

All authors attest that they meet the current International Committee of Medical Journal Editors (ICMJE) criteria for Authorship.

References

- [1] COVIDSurg Collaborative. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet Lond Engl* 2020;396:27–38.
- [2] Mathiesen T, Arraez M, Asser T, Balak N, Barazi S, Bernucci C, et al. A snapshot of European neurosurgery December 2019 vs. March 2020: just before and during the Covid-19 pandemic. *Acta Neurochir (Wien)* 2020;162:2221–3.
- [3] Ganau M, Netuka D, Broekman M, Zoia C, Tsiannaka E, Schwake M, et al. Neurosurgeons and the fight with COVID-19: a position statement from the EANS Individual Membership Committee. *Acta Neurochir (Wien)* 2020;162:1777–82.
- [4] Minhas Z, Ganau M, Thakar C, Reynolds J, Rothenfluh D, Bojanic S, et al. COVID-19: new challenges, risks, and the future provision of care in spinal services. *Bone Jt J* 2020;102-B:655–7.
- [5] Grelat M, Pommier B, Portet S, Amelot A, Barrey C, Leroy H-A, et al. Patients with Coronavirus 2019 (COVID-19) and surgery: guidelines and checklist proposal. *World Neurosurg* 2020;139:e769–73.
- [6] Wen J, Qi X, Lyon KA, Liang B, Wang X, Feng D, et al. Lessons from China When performing neurosurgical procedures during the coronavirus disease 2019 (COVID-19) pandemic. *World Neurosurg* 2020;138:e955–60.
- [7] Zoia C, Bongetta D, Veiceschi P, Cenzato M, Di Meco F, Locatelli D, et al. Neurosurgery during the COVID-19 pandemic: update from Lombardy, northern Italy. *Acta Neurochir (Wien)* 2020;162:1221–2.
- [8] Germanò A, Raffa G, Angileri FF, Cardali SM, Tomasello F. Coronavirus disease 2019 (COVID-19) and neurosurgery: literature and neurosurgical societies recommendations update. *World Neurosurg* 2020;139:e812–7.
- [9] Chibbaro S, Ganau M, Todeschi J, Proust F, Cebula H. How SARS-CoV-2 is forcing us to reconsider and reorganize our daily neurosurgical practice. *Neurochirurgie* 2020;66:189–91.
- [10] Société française de neurochirurgie. Recommandations pour la prise en charge des pathologies neurochirurgicales en période de crise liée à la Covid-19; 2020.
- [11] Tartara F, Cofano F, Zenga F, Boeris D, Garbossa D, Cenzato M. Are we forgetting non-COVID-19-related diseases during lockdown? *Acta Neurochir (Wien)* 2020;162:1501.
- [12] Jean WC, Ironside NT, Sack KD, Felbaum DR, Syed HR. The impact of COVID-19 on neurosurgeons and the strategy for triaging non-emergent operations: a global neurosurgery study. *Acta Neurochir (Wien)* 2020;162:1229–40.
- [13] Hulsbergen AFC, Eijkholt MM, Balak N, Brennum J, Bolger C, Bohrer A-M, et al. Ethical triage during the COVID-19 pandemic: a toolkit for neurosurgical resource allocation. *Acta Neurochir (Wien)* 2020;162:1485–90.
- [14] Poorolajal J, Cheraghi Z, Irani AD, Rezaeian S. Quality of Cohort Studies Reporting Post the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement. *Epidemiol Health* 2011;33:e2011005.
- [15] Rubulotta F, Soliman-Aboumarie H, Filbey K, Geldner G, Kuck K, Ganau M, et al. Technologies to optimize the care of severe coronavirus disease 2019 patients for health care providers challenged by limited resources. *Anesth Analg* 2020;131:351–64.
- [16] Patel ZM, Fernandez-Miranda J, Hwang PH, Nayak JV, Dodd R, Sajjadi H, et al. Letter: precautions for endoscopic transnasal skull base surgery during the COVID-19 pandemic. *Neurosurgery* 2020;87:E66–7.
- [17] Mattogno PP, Rigante M, Lauretti L, Parrilla C, D'Alessandris QG, Paludetti G, et al. Transnasal endoscopic skull base surgery during COVID-19 pandemic: algorithm of management in an Italian reference COVID center. *Acta Neurochir (Wien)* 2020;162:1783–5.
- [18] Bernat A-L, Gaberel T, Giammattei L, Rault F, Gakuba C, Magro E, et al. Intracranial hemorrhage related to brain vascular disease and COVID-19 containment: where are the patients? *Neurochirurgie* 2020;66:400–1.
- [19] Hecht N, Wessels L, Werft F-O, Schneider UC, Czabanka M, Vajkoczy P. Need for ensuring care for neuro-emergencies—lessons learned from the COVID-19 pandemic. *Acta Neurochir (Wien)* 2020;162:1795–801.