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Coronavirus Disease 2019 (COVID-19) and Neurosurgery: Literature and Neurosurgical Societies Recommendations Update

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■ **BACKGROUND:** Since January 2020, when the pathogen causing the coronavirus disease was identified in humans, the literature on coronavirus disease 2019 (COVID-19) has grown exponentially to more than 4000 publications. There is the need to provide an update for each single medical discipline, including neurosurgery, to be used by single professionals or to be distributed through the neurosurgical community and to be used by governments in designing new scenario of care.

■ **METHODS:** A review of the MEDLINE database was performed on April 13, 2020. Search terms included "COVID-19," "neurosurgery," and "surgery." A review of documents published on the webpage of the WFNS (World Federation of Neurosurgical Societies) and of the 5 continental associations of neurosurgical societies, AANS (American Association of Neurological Surgeons), AASNS (Asian Australasian Society of Neurological Surgeons), CAANS (Continental Association of African Neurosurgical Societies), EANS (European Association of Neurosurgical Societies), and FLANC (Latin American Federation of Neurosurgical Societies), representing the 119 national neurosurgical societies around the world, was performed.

■ **RESULTS:** The literature search yielded 38 results that were manually reviewed. Fourteen manuscripts were considered eligible. They described suggestions and considerations to optimize care of neurosurgical patients, editorials on operational models, perspectives from neurosurgical departments, letters to the editor describing experiences on how to help

medical staff to be prepared in advance for pandemic situations, and descriptions of regional or departmental models and/or organizational schemes. The webpages of the searched societies reported a total of 57 documents.

■ **CONCLUSIONS:** The neurosurgical scientific community has promptly reacted to the COVID-19 outbreak by producing a growing number of documents that could serve as guidance for neurosurgeons all over the world. Neurosurgical societies will represent the key institutions for guiding the neurosurgical community to overcome the COVID-19 crisis.

INTRODUCTION

Since January 2020, when the pathogen causing the coronavirus disease pneumonia was identified as the cause of disease in humans, the literature on coronavirus disease 2019 (COVID-19) has grown exponentially, from no manuscripts to more than 4000 publications at the time of this reporting. Moreover, as it is evidently a pandemic, it has diffused throughout the entire worldwide human community at different levels, and, in the medical fields, it has involved numerous disciplines, not limited to virology, epidemiology, infectious disease, critical care medicine, pediatrics, and medical education but also psychiatry and surgery, including neurosurgery.

As the number of scientific reports increases daily, there is a need to provide an update for each medical discipline, including neurosurgery, to provide updates and recommendations, if available. This information should be used not only by individual

Key words

- AANS
- AASNS
- CAANS
- COVID-19
- Coronavirus
- EANS
- FLANC
- Neurosurgery
- WFNS

Abbreviations and Acronyms

AANS: American Association of Neurological Surgeons

AASNS: Asian Australasian Society of Neurological Surgeons

CAANS: Continental Association of African Neurosurgical Societies

COVID-19: Coronavirus disease 2019

EANS: European Association of Neurosurgical Societies

FLANC: Latin American Federation of Neurosurgical Societies

WFNS: World Federation of Neurosurgical Societies

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professionals on how to treat a single case and disseminated through the neurosurgical community, including neurosurgical societies, but also should be helpful for governments in planning and implementing new management strategies for future medical epidemics and other disasters, and for reorganizing neurosurgical care.

METHODS

Literature Review

A review of the MEDLINE database (PubMed - National Library of Medicine) was performed on Monday, April 13, 2020, for articles published in the English language from October 1952 to date. Search terms included “COVID-19,” “neurosurgery,” and “surgery.” We reviewed search results to assess the relevance of publications on this topic, including case reports. References from eligible articles were reviewed to locate other articles of interest.

Neurosurgical Societies Webpages

A review of documents published on the topic of COVID-19 on the webpage of the World Federation of Neurosurgical Societies (WFNS, www.wfns.org) and of the 5 continental associations of neurosurgery (AANS, American Association of Neurological Surgeons, www.aans.org; Asian Australasian Society of Neurological Surgeons, AASNS, www.aasns.org; Continental Association of African Neurosurgical Societies, CAANS, www.caans.org; European Association of Neurosurgical Societies, EANS, www.eans.org; and Latin American Federation of Neurosurgical Societies, FLANC, www.flanc.la) was conducted on the same day. The WFNS and the continental associations of neurologic surgery websites were chosen for review, as they are representative of the 119 national neurosurgical societies around the world, thereby avoiding both the scarcity of webpage presence of some national neurosurgical societies and the difficulty of multiple-language interpretation.^{1,2}

RESULTS

The literature yielded an initial set of 38 results that were reviewed for relevance to neurosurgery and COVID-19. We included only articles published in the English language. Only one article in Chinese language was found and excluded (<http://rs.yiigle.com/yufabiao/1187863.htm>).³

Others were excluded despite their PubMed citation, which did not specifically address neurosurgical issues on the COVID-19 pandemic. These excluded articles focused on descriptions of out-of-hospital cohort management, treatment options for corona virus infections, familial clusters of severe respiratory syndrome coronavirus 2 infections, diagnosis of the disease, epidemic-control measures for prevention of pandemic diffusion, risk factors for COVID-19 infection, maxillofacial trauma with neurologic diseases, meningitis/encephalitis associated with COVID-19, and psychological care of involved medical staff.

Fourteen reports were considered eligible for inclusion in the present report, which included suggestions and considerations to optimize care of neurosurgical patients,⁴⁻⁶ editorial commentaries on operational models,⁷⁻¹² perspectives from neurosurgical departments,¹³ letters to the editor describing experiences with medical staff preparations in advance of pandemic

situations,^{14,15} and descriptions of regional or departmental models and/or organizational scheme.^{7,16,17} Three main topics were discussed in these papers: “triage and management of neurosurgical patients/practice recommendations,” “reorganization models for neurosurgical departments,” and “current neurosurgical practice in most affected countries.”

The search of neurosurgical society webpages resulted in a total of 57 documents (Table 1), dealing with 7 main topics: “general information regarding COVID-19,” “general messages from neurosurgical societies,” “triage and management of neurosurgical patients/practice recommendations,” “reorganization models for neurosurgical departments,” “neurosurgery residents education,” “surveys on neurosurgical practice in most affected countries,” and “personal protective equipment” (Table 2). These documents include 3 presidential addresses; 1 presidential message, 1 administrative committee message; 1 document in support of a position paper from a national general surgery society, 1 audio interview; 1 weekly webinar series discussing a variety of COVID-19 topics of interest to neurosurgeons; 2 webinars, 2 links to national neurosurgical societies where a specific COVID-19 section was present; 1 article offering advice on triaging nonemergent neurosurgical procedures; 1 regional update from departments of neurosurgery located in a region severely affected by COVID-19; 8 links to scientific manuscripts or letters to journal editors reporting neurosurgically relevant aspects of COVID-19; 2 surveys designed to understand how neurosurgical departments are facing the epidemic; 1 handbook describing methods to prevent and treat COVID-19 according to clinical experience; 1 statement from a national neurosurgical society; 2 recommendations on elective surgery; 1 neurosurgeon’s guide to pulmonary critical care of COVID-19; 11 documents reporting government information and resources; 1 telemedicine services coding white paper; 3 links to major international scientific journals’ COVID-19 information for continuing medical education and clinical information; 10 advocacy efforts dedicated to a number of political recommendations, including how to support and sustain physicians and their practices during this unprecedented national emergency through tax relief, no interest loans, direct payments, payment for virtual visits including telephone calls and other measures; and 3 obituaries dedicated to neurosurgeons and doctors who have been lost due to the disease. Since the FLANC webpage is in Spanish, only the link to a webinar in English and to a bulletin on COVID-19 in Spanish were included. In addition, the CAANS had both Arabic and English versions, but no documents on COVID-19 were found.

The EANS webpage included 2 scientific manuscripts addressing, respectively, the computed tomography and magnetic resonance imaging features of COVID-19 associated with hemorrhagic necrotizing encephalopathy and the neurologic manifestations of hospitalized patients with COVID-19 in Wuhan, China, that were not found in the PubMed search.^{18,19} Therefore, the total number of manuscripts relevant to COVID-19 and neurosurgery found to date is 16.

DISCUSSION

Despite a total number of 1.9 million reported cases of individuals infected with COVID-19 to date worldwide, with only 441,000

Table 1. Summary of the COVID-19 Documents Presented in the Webpages of the Neurosurgical Societies

Society	Document Title/Description	Web Address
WFNS	Presidential address	https://www.wfns.org/news/84/wfns-president-s-message-covid-19-virus
	Neurosurgery during the COVID-19 pandemic: update from Lombardy, northern Italy	https://www.wfns.org/WFNSTData/Uploads/files/acta-covid-3032020.pdf
	The Survey from Chief of WFNS Web and Publication Committee	https://www.wfns.org/news/86/the-survey-from-chief-of-wfns-web-and-publication-committee-dr-marco-maria-fon
	Handbook of COVID-19 Prevention and Treatment	https://www.wfns.org/WFNSTData/Uploads/files/Handbook-COVID19-GlobalMediXChange.pdf
	Hong Kong Neurosurgical Society COVID-19 statement	https://www.ns.org.hk/post/hkns-covid-19-statement
	Webinar for Neurosurgical Education - Neurosurgical practice during the pandemic—Learnings from the world's most affected countries	https://www.globalneuro.org/EN/webinar.html
AANS	Presidents Message	https://www.aans.org/COVID-19-Update/Presidents-Message
	Webinar series	https://www.aans.org/Education/COVID-19-Neurosurgery-Resources
	Neurosurgeon's guide to pulmonary critical care for COVID-19	https://www.aans.org/-/media/Files/AANS/COVID19-ICU-Tutorial-JSNTCC.ashx?la=en&hash=FA8C43C6118568C32F06605FD611EC5227A725DF
	CMS adult elective surgery and procedures recommendations on elective surgery	https://www.cms.gov/files/document/cms-non-emergent-elective-medical-recommendations.pdf
	ACS recommendations for management of elective surgical procedures	https://www.facs.org/covid-19/clinical-guidance/elective-surgery
AASNS	Administrative Committee message	http://www.aasns.org/wp-content/uploads/2020/04/covid-19.jpg
EANS	Presidential address	https://www.youtube.com/watch?v=QILGwTYQPI0
	Presidential message	https://link.springer.com/epdf/10.1007/s00701-020-04306-9
	EANS advice: Triaging non-emergent neurosurgical procedures	https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/eans_advice2020_corona.pdf
	Non-elective surgical interventions by German Neurosurgeons DGNC - BDNC	https://www.dgnc.de/fileadmin/media/dgnc_homepage/publikationen/downloads/DGNC_BDNC_non-elective_surgical_interventions.pdf
	Survey — Questionnaire regarding Neurosurgery across Europe	https://www.surveymonkey.de/r/PG8GYGS
	COVID-19—associated Acute Hemorrhagic Necrotizing Encephalopathy: CT and MRI Features	https://pubs.rsna.org/doi/10.1148/radiol.2020201187
	Coronavirus and the Brain	https://sapienlabs.org/coronavirus-and-the-brain/
	At the Epicenter of the Covid-19 Pandemic and Humanitarian Crises in Italy	https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0080
	Audio interview: New Research on Possible Treatments for Covid-19	https://www.nejm.org/doi/full/10.1056/NEJMe2005759?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed
	Evidence of the COVID-19 Virus Targeting the CNS	https://pubs.acs.org/doi/10.1021/acscemneuro.0c00122
	Neurological Manifestations of Hospitalized Patients with COVID-19 in Wuhan, China	https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/neurological_manifestations_.pdf
	Coronavirus infection of the central nervous system	https://www.nature.com/articles/nrmicro1343.pdf?platform=oscar&draft=collection
	Demyelinating encephalomyelitis induced by a long-term corona virus infection in rats	https://www.ncbi.nlm.nih.gov/pubmed/220834
	Early and late CNS-effects of corona virus infection in rats	https://www.ncbi.nlm.nih.gov/pubmed/211826
	Letter: The Coronavirus Disease 2019 Global Pandemic: A Neurosurgical Treatment Algorithm	https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/nyaa116.pdf.pdf
	The Society of British Neurological Surgeons - SBNS	https://www.sbns.org.uk/index.php/policies-and-publications/covid/
The Italian Society of Neurosurgery - SINCh	http://www.sinch.it/news/covid-and-neurosurgery-10	
Impact of COVID-19 on Neurosurgery - International Webinar Symposium	http://www.nurgery.org/index.htm	
FLANC	Global Neuro—Neurosurgical Special Report 2019-nCoV	http://flanc.la/exibir.php?id=4639

COVID-19, coronavirus disease 2019; WFNS, World Federation of Neurosurgical Societies; AANS, American Association of Neurological Surgeons; AASNS, Asian Australasian Society of Neurological Surgeons; EANS, European Association of Neurosurgical Societies; FLANC, Latin American Federation of Neurosurgical Societies.

Table 2. Documents on COVID-19 Available on the Webpages of the Neurosurgical Societies, Sorted by the Main Covered Topic, with the Respective Web Link

Topic	Web Address
General information regarding COVID-19	https://www.nejm.org/doi/full/10.1056/NEJMe2005759?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed
	https://www.nature.com/articles/nrmicro1343.pdf?platform=oscar&draft=collection
	https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/neurological_manifestations_.pdf
	https://sapienlabs.org/coronavirus-and-the-brain/
	https://pubs.acs.org/doi/10.1021/acscchemneuro.0c00122
	https://www.ncbi.nlm.nih.gov/pubmed/220834
	https://www.ncbi.nlm.nih.gov/pubmed/211826
	https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/nyaa116.pdf.pdf
General messages from neurosurgical societies	https://www.wfns.org/news/84/wfns-president-s-message-covid-19-virus
	https://www.aans.org/COVID-19-Update/Presidents-Message
	http://www.aasns.org/wp-content/uploads/2020/04/COVID-message.docx
	https://www.youtube.com/watch?v=QILGwTYQPI0
	https://link.springer.com/epdf/10.1007/s00701-020-04306-9
Triage and management of neurosurgical patients/practice recommendations	http://flanc.la/exibir.php?id=4639
	https://www.ns.org.hk/post/hkns-covid-19-statement
	https://www.aans.org/Education/COVID-19-Neurosurgery-Resources
	https://www.aans.org/-/media/Files/AANS/COVID19-ICU-Tutorial-JSNTCC.ashx?la=en&hash=FA8C43C6118568C32F06605FD611EC5227A725DF
	https://www.cms.gov/files/document/cms-non-emergent-elective-medical-recommendations.pdf
	https://www.facs.org/covid-19/clinical-guidance/elective-surgery
	https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/eans_advice2020_corona.pdf
	https://www.dgnc.de/fileadmin/media/dgnc_homepage/publikationen/downloads/DGNC_BDNC_non-elective_surgical_interventions.pdf
	https://pubs.rsna.org/doi/10.1148/radiol.2020201187
	https://www.sbns.org.uk/index.php/policies-and-publications/covid/
Reorganization models for neurosurgical departments	http://www.sinch.it/news/covid-and-neurosurgery-10
	https://www.wfns.org/WFNData/Uploads/files/acta-covid-3032020.pdf
Neurosurgery residents' education	https://catalyst.nejm.org/doi/full/10.1056/CAT.20.0080
	https://www.globalneuro.org/EN/webinar.html
	http://www.nsurgery.org/index.htm
Surveys on neurosurgical practice in most affected countries	https://www.aans.org/Education/COVID-19-Neurosurgery-Resources
	https://www.wfns.org/news/86/the-survey-from-chief-of-wfns-web-and-publication-committee-dr-marco-maria-fon
Personal protective equipment	https://www.surveymonkey.de/r/PG8GYGS
	https://www.wfns.org/WFNData/Uploads/files/Handbook-COVID19-GlobalMediXChange.pdf
COVID-19, coronavirus disease 2019.	

recovered, and most importantly, 119,000 deaths, and a total number of 4000 scientific manuscripts published in the medical literature in 3 months, only 0.4% of published reports are relevant to neurosurgery. It may be hypothesized that, despite a long tradition of neurosurgical contribution to basic and translational science and research, little awareness exists in the neurosurgical community of the COVID-19 pandemic. Therefore, there is a need not only to increase awareness of the disease per se, but also, and more importantly, to establish new concepts of organization of neurosurgical practice and education.

The PubMed and web search performed yielded only 7 scientific manuscripts addressing the topic of neurosurgery and COVID-19,^{4-6,11,18-20} the remaining 4 being letters to the editor^{7,14,15,17} or editorials.^{8-10,12,16} Within these reports, some recommendations can be found that may be useful for neurosurgical practice in this pandemic.

Globally, there has been a broad call to reduce “elective” neurosurgical operations with the aim to minimize potential exposure of fragile neurosurgical patients with diseases other than COVID-19. Consequently, neurosurgeons are expected to devise alternative plans of how and when to treat nonemergent neurosurgical patients. Nonetheless, apart from clear-cut emergent cases, the timing of neurosurgery may be crucial, even in some elective procedures such as intracranial tumors or cervical myelopathy. These situations often require decision-making coordinated with senior neurosurgeons. At this point, only published literature, reports, and suggestions could truly represent guidance for the worldwide neurosurgical community facing such a complex decision-making process.

Burke et al.⁷ performed a literature review and consulted Chinese neurosurgeons who provided firsthand knowledge of how neurosurgical cases were scheduled during the peak of the COVID-19 outbreak in China. They included those recommendations as discussion points in the Evidence Review Panel. They tried to schedule neurosurgical cases according to the level of viral disease in the community, staffing shortage, and related recommendations for emergent, urgent, and elective procedures. They then proposed a checklist for neurosurgical cases according to the level of urgency and availability of operating rooms and post-operative beds. The decision is made through a peer-review process for patient selection.⁷

This paper is an important systematic attempt to address the problems of neurosurgical practice in the COVID-19 era. There are, however, no worldwide guidelines applicable to different settings varying for virus surge and its related evolving and unpredictable situations, local hospital and health organizations, and availability of operating rooms, intensive care unit beds, and staffing.

General recommendations have been suggested by the American College of Surgeons: “Each hospital, health system, and surgeon should thoughtfully review all scheduled elective procedures with a plan to minimize, postpone, or cancel electively scheduled operations, endoscopies, or other invasive procedures until we have passed the predicted inflection point in the exposure graph and can be confident that our health care infrastructure can support a potentially rapid and overwhelming uptick in critical patient care needs” (<https://www.facs.org/covid-19/clinical-guidance/elective-surgery>).

These recommendations were adopted in the EANS website proposals: “Triaging non-emergent neurosurgical procedures during the COVID-19 outbreak” (https://cdn.ymaws.com/www.eans.org/resource/resmgr/documents/corona/eans_advice2020_corona.pdf). This scale is similar to the tiering of elective scheduling proposed by Burke et al.⁷ but has the advantage of listing examples of neurosurgical diseases and related actions.

In fact, although some surgeries can be delayed for a significant period of time, others need to be scheduled more promptly, despite the pandemic, because of the risk of illness progression by delay (i.e., malignant brain tumors and vascular disease). With this in mind, it must be understood that the choice to postpone an operation must be made with consideration of medical and logistical factors, as no one can anticipate the influence of COVID-19 in the near or more distant future, and individual cases might be deemed emergencies that cannot be safely delayed.

With this in view, the EANS recommends triage of neurosurgical cases based on a classification of emergency. This instrument is based on the Elective Surgery Acuity Scale from St. Louis University (<https://www.facs.org/>). Although the tool gives models of neurosurgical procedures in almost every group, it should remain up to national neurosurgical societies to create specific triage systems based on regional and/or local capacity.

Surprisingly, despite decades of telemedicine in caring for patients remotely, including neurosurgery,²¹ and the use of this technology in this pandemic,²² in the present search no report described the use of this technology among the neurosurgery centers for the treatment of patients during the COVID-19 pandemic. Direct-to-consumer telemedicine may allow patients to link with their health care provider at a distance. This virtual platform could be used by smartphones or webcam-enabled computers and could physicians to effectively screen patients with early signs of COVID-19 before reaching the hospital.

Another topic of interest is the maintenance of essential standard medical and surgical education among students and residents during epidemic conditions. In Italy, as neurosurgical daily activities were drastically reduced and limited only to procedures that could not be deferred, some senior faculty became engaged in emergency management, reducing their neurosurgical availability and teaching time. It is evident that this unprecedented crisis has an impact on resident and medical student training, considering that it is very difficult to predict the duration of the pandemic. For teaching purposes, webinars, seminars, or other presentations should take place on the Internet, allowing participants in different locations to see and hear the presenter, ask questions, and occasionally respond to polls. At present, only 2 webinars, namely one supported by the WFNS (Neurosurgical Special Report 2019-nCov - Neurosurgical practice during the pandemic - Learnings from the world’s most affected countries) (<https://www.globalneuro.org/EN/webinar.html>) and another by the EANS (Impact of COVID-19 on Neurosurgery - International Webinar Symposium) (<https://www.nsurgery.org/index.htm>) and 1 weekly seminar series organized by the AANS (AANS COVID-19 Webinar Series) (<https://www.aans.org/Education/COVID-19-Neurosurgery-Resources>) discussing a variety of COVID-19 topics of interest to neurosurgeons, have been organized, and more should be encouraged.

CONCLUSIONS

The recent COVID-19 outbreak has strongly impacted neurosurgical practice all over the world, often confusing both patients and neurosurgeons. The neurosurgical scientific community, especially led by the 5 continental associations of neurosurgical societies, has promptly reacted by producing a growing number of documents that could serve as guidance for neurosurgeons all over the world. Nevertheless, the drafting of recommendations and guidelines for the best neurosurgical practices in the COVID-19 era is still ongoing. We strongly believe that, during these difficult times, a daily referral to the neurosurgical societies' webpages will represent a key tool to spread information, suggestions, considerations, and models to optimize care of neurosurgical patients all over the world, as well as to maintain high standards of surgical

education, thus guiding the neurosurgical community through the COVID-19 crisis.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Antonino Germanò: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision. **Giovanni Raffa:** Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Funding acquisition. **Filippo Flavio Angileri:** Conceptualization, Writing - original draft, Writing - review & editing, Supervision. **Salvatore Massimiliano Cardali:** Conceptualization, Writing - original draft, Writing - review & editing, Supervision. **Francesco Tomasello:** Conceptualization, Writing - original draft, Writing - review & editing, Supervision.

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