COVID-19 and Neurosurgery: A Comprehensive Review of Literature

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Abstract

The 2019 Coronavirus Infection (COVID-19) first appeared in Wuhan, Hubei Province, China, in December 2019 and has disseminated rapidly to almost every region of the world to become a pandemic. COVID-19 is initiated by severe acute respiratory syndrome CoV-2. The principal signs and symptoms are related to the respiratory and cardiovascular systems; however, the nervous system is another primary target of this devastating disease, according to numerous case reports and some reviews that have been published. Moreover, neurosurgical issues have also been dramatically affected. This comprehensive review aims to summarize the impact of COVID-19 on neurosurgical issues. In addition, we aim to serve as a reference for neurosurgeons dealing with neurosurgical cases of the disease. The article emphasized neurological display of COVID-19, neurosurgical practice, contagion control and precautions, residency, and education in neurosurgery, neurosurgeons' mental health. In addition to that, the article also provides some recommendations.

Introduction

A series of pneumonia cases with an unknown origin was identified in Wuhan, China, in December 2019, likely linked to a seafood market. On January 8, 2020, a medical article on this pneumonia and the risk of global dissemination through commercial air travel was published in the Journal of Travel Medicine (1). Clinical and epidemiological studies followed and identified the COVID-19 is caused by the virus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (2). Since the identification of COVID-19, thousands of papers and studies have been published in numerous disciplines, such as infectious disease, medicine, psychiatry, epidemiology, and surgery. Neurosurgery was one of the primary disciplines affected by SARS-CoV-2, where case reports of patients were published, elective procedures postponed, residency and training programs delayed, and many more. The current research aimed to discuss the literature review to address this issue. The research was conducted to view myriads of already published articles and case reports to provide updates about neurological issues. The article also provides insights from different regions of the world and delivers the impetus for establishing guidelines.

Materials And Methods

A review of the PubMed database (the National Library of Medicine) was performed on August 5, 2021, for all articles published on the topic. The search terms used were "neurosurgery" and "SARS-CoV-2." The results obtained 1081 articles, which were reviewed, but only 45 articles were included. Other articles were excluded as they are on different topics such as clinical and neurological manifestations, diagnosis, examination, and treatment of COVID-19, risk factors of COVID-19, and COVID-19 in other disciplines like cardiothoracic surgery, orthopaedic surgery, neuro-anesthesia, emergency medicine and neurology. References from the included articles were also reviewed, and the relevant ones were further included.

Results

The literature revealed 1081 results. Of which, 45 relevant articles were included. These articles reported on neurological implications of COVID-19 (3–9), difficulties in patients with COVID-19 undergoing surgeries (10), proposed development suggestions for the neurosurgery patients (11–17), letters to editors (18), recommended personal protective equipment (PPE) for surgeons (19), and infection prevention strategies (20–23). In addition, others articles reported on experiences from different countries (2, 24–31), international surveys on neurosurgeons (32, 33), proposed exit strategies for resuming surgeries (34), telemedicine use in neurosurgery (35), how COVID-19 affected education and training in neurosurgery (36, 37), and mental health among neurosurgeons (38, 39).

Discussion

A survey of 1070 specimens obtained from 205 patients was conducted to identify the manifestations of COVID-19 SARS-CoV-2 RNA (20, 40). Neurological manifestations were present in 93% of bronchoalveolar lavage organisms, 72 % of sputum, 63 % of nasal swabs, 46 % fiber bronchoscope brush biopsies, 32 % of pharyngeal swabs, 29 % of faeces, and 1% of human blood samples. SARS-CoV-2 has also been shown to have tropism for the nervous system and preference for neurons in many studies since the brain expresses Angiotensin-converting enzyme 2 (ACE2) receptors on glial cells and neurons, and SARS-CoV-2 uses mRNA to express proteins like S1 protein, which allows it to bind to the cell membrane by interfering with ACE2 receptors (6). The gestation period for SARS-CoV-2 is around five days, and almost all patients develop symptoms within 14 days of exposure (41, 42).

Patients infected with SARS-CoV-2 can be symptom-free in up to 87 percent of cases, but they are deemed infectious carriers capable of transmitting the virus (43). Fever, coughing, chronic fatigue, weakness, expectoration, and oedema are the major clinical signs of COVID-19 (44). In addition to respiratory and systemic symptoms, 36.4 percent of COVID-19 patients experience neurological symptoms of pain, confusion, and numbness. Moreover, patients with severe infections, including elderly patients, had neurological manifestations, underlying comorbidities and showed few usual COVID-19 signs like fever and coughing (45). Studies have shown that the involvement of organ systems other than the respiratory system increases the morbidity and mortality in COVID-19 cases (46).

Patients who are older or have comorbid conditions like diabetes, cardiopulmonary infection, or immune suppression are more prone to undergo more severe disease, including death (47). In addition, COVID-19 can cause a systemic prothrombotic condition, leading to cerebrovascular injuries (48). In a randomized controlled trial, people were diagnosed with repeated gustatory and olfactory disabilities (49). In March 2020, the first case of viral encephalitis caused by SARS-CoV-2 was reported in Beijing Ditan Hospital, China, confirmed by genome sequencing in the CSF (50). Following that, cases of SARS-CoV-2 encephalitis were identified. The disease was determined by reverse transcription-polymerase chain reaction (RT-PCR) from the patient's CSF, given the virus's absence from the nasopharyngeal swab sample (3).

Furthermore, another encephalitis case associated with SARS-CoV-2 that was self-limiting was reported (4). Duong et al. said that encephalitis had been the sole presentation in patients without respiratory symptoms (51). The authors treated the case with arbidol, oxygen therapy, and mannitol.

The pathophysiology speculated was that the SARS-CoV-2-induced immunological response might have caused the inflammatory injury and oedema, leading to an alteration in consciousness (52). SARS-CoV-2 can also cause neurological issues, including polyneuropathy, encephalopathy, and demyelinating tumours in the spine (53). Furthermore, reports of Guillain–Barré syndrome caused by SARS-CoV-2 have been reported (5). In patients with severe SARS-CoV-2 infection, a

French study found that cerebral perfusion was altered (54). Another case was reported on spontaneous intracerebral haemorrhage due to COVID-19 (7). To avoid delayed diagnosis, clinicians need to consider SARS-CoV-2 as a differential diagnosis for neurological manifestations, including mild ones, such as hypogeusia and hyposmia. A literature review published in June 2020 showed 47 cases of cerebrovascular diseases during the COVID-19 epidemic (8). An occurrence of arterial dissection that could potentially be an unusual complication of COVID-19 was also reported (9).

Neurosurgical experience from several countries

There was a worldwide redistribution of healthcare services to expand healthcare capability—workers serving patients with COVID-19. For example, in Italy, the Lombard Regional Health System was restructured into a new Center and Spoke framework, with "Center facilities" handling neurosurgical and spinal crises and "Spoke hospitals" dealing with COVID-19 administration (30). According to reports, after the outbreak, at least half of all medical and surgical operations have been canceled. In reference to to a cohort study in the Wuhan region, operations on patients with COVID-19 are related to higher mortality, with nearly half of those with COVID-19 requiring critical care admissions postoperatively and 20.5 percent dying (55).

Similarly, a study at the University of Brescia, Italy, confirmed that the death rate of patients with COVID-19 associated with chronic subdural hematoma was 80% (9). Diagnosis of pulmonary complications can occur in half of the cases with a positive preoperative diagnosis and are linked to a higher mortality rate, especially in males over 70 years old (10). In areas designated as centres of a health emergency, such as Lombardy, Italy, where 30,000 confirmed cases were present by April 19, 2020, surgery was determined to be centralized in high-volume centres, and neurosurgical divisions were reorganized (24).

Infection control and precautions

The surgical teams involved have to be fully protected using properly fitted PPEs. Catheterization and resuscitation, surgical interventions that reveal the respiratory or gastrointestinal tract, and the use of

aerosol-producing devices such as drills, debriders, and electrocautery have all been classified as high-risk practices (19). Neurosurgeons should delay transsphenoidal, transoral, and transmastoid approaches, as well as craniotomies involving the frontal sinuses or substituted by other similar approaches. In addition, it's a good idea to keep the use of aerosol-generating tools to a minimum and substituting them with, for example, curettes, rongeurs, or Hudson braces (13). It is also preferable to consider transcranial or sublabial approach avoiding the exposure to mucosa (23). Moreover, intubations and extubations should be done with anesthesia staff with maximum PPEs. Operating room staff should only enter the room when the air has been cleaned (21).

A worldwide survey was conducted on neurosurgeons' perception of COVID-19 safeguards. The survey showed that 58% of neurosurgeons reserved dedicated routes to positive patients, where particular surgery rooms and units for neurosurgery were established. On the contrary, just 21% said they did not take any extra precautions with positive patients (32).

Residency and education in neurosurgery

According to a survey that has been circulated to neurosurgical residents, it has been deduced that most of them have the basic scientific knowledge germane to COVID-19; however, concerning PPE, they are not well prepared to properly use it. In addition, their clinical training has been significantly altered (33). This pandemic has changed the way we deliver and digest information; particularly, virtual learning and other forms of technology have been forcibly implemented to resume residency programs (36). These new-era meetings permitted conferences to be held regionally and globally. Many neurological organizations have included virtual materials and educational tools within their official websites (56). It has been proven that this state-of-the-art way of learning is very effective and convenient. Cell phones have played a key role during the pandemic, especially concerning self-isolation periods and travel restrictions. All types of journals, E-books, meetings, and conferences can be accessed by cell phones. A survey performed in the United States showed that roughly 65% of neurosurgical residents chose the virtual learning method over standard ones. It can be deduced that neurosurgical training may rely on such technology for learning to communicate with international experts (37).

Neurosurgeons' mental health

According to a study, approximately 14% of neurosurgeons claimed that they have depression. Thus, the psychological impact of being a clinician is a huge concern, especially the thought of being unprotected and worrying about the possibility of contracting the disease themselves and transmitting it to their family members. That being mentioned, neurosurgeons and other clinicians' safety must be maintained by following complete precautions and making sure that all safety procedures are strictly adhered to (38). On the other hand, a national survey showed that the overall burnout rate among neurosurgical residents

was 26.1% and the overall rate of career satisfaction was 73.9%. This results from few work hours, uncertainty about healthcare reform and that COVID-19 might affect achieving surgical milestones. Moreover, residents more likely to experience burnout are those earlier in training, those who do not want to pursue neurosurgery again, and those who experienced altered rotation and vacation scheduling (39).

Recommendations

The American College of Surgeons recommends that doctors and consultants postpone optional cases during the COVID-19 pandemic (57). The system for treating neuro-oncological cases was developed by the American Society of Neurological Surgeons/Congress of Neurological Surgeons Tumor Division and the Society for Neuro-Oncology (11). The criteria for emergency neurosurgical care are identical in all systems. Neurosurgical crises must be treated according to established expertise and practice (11, 12). In cases of traumatic brain injury that require emergent interventions, time can be saved by performing CT chest instead of RT-PCR (15). Any patient undergoing non-emergent surgery should be tested for COVID-19 as recommended by the Royal Surgical College of UK (58). For low-grade gliomas, it is recommended to observe the growth by repeat MRI in 3–6 months rather than active treatment, and diagnostic surgery and adjuvant therapy can be delayed if the patient is stable (14). Specific procedures such as awake craniotomies in patients with low-grade glioma have to be performed when the presence of COVID-19 is ruled out (18). However, maximal resection should be performed in patients with high-grade gliomas to ensure a definitive diagnosis (14). There are recommendations on managing high-grade gliomas (12), sinonasal, and anterior skull base cancers (16) during the pandemic. There are also recommendations for managing subarachnoid haemorrhage (17).

Other recommendations include that outpatient practice can be done via telemedicine (13). A systematic review of literature indicated that telemedicine was equivalent or superior to alternative patient encounter mediums in 15 out of 16 studies, and concluded that neurosurgical telemedicine encounters appear promising in resource-scarce times (35). Physical appointments should be limited to patients who need wound care and stitch extraction.

The most appropriate technique for elective neurosurgical operations is anticipated to be the abundance of testing and the emergence of the so-called herd immunity (59). Hopefully, if clinicians acquire herd immunity via natural infection or through vaccination, then they could be assigned safely to care for patients with COVID-19.

Conclusions

Our literature review summarizes the main impact of the current and ongoing global pandemic, COVID-19, on neurosurgical issues, including neurological manifestations of COVID-19, neurosurgical practice, residency and education in neurosurgery, and neurosurgeons' mental health. All these points taken together, we recommend postponing non-emergent elective cases in areas with high COVID-19 rates,

whereas neurosurgical emergencies have to be handled with appropriate infection control measures as aforementioned. In case of clinical suspicion, we recommend screening all patients before admission. With regard to outpatient management, it is ideal to contact patients via telemedicine. In the future, elective neurosurgical cases can be normally resumed upon the achievement of herd immunity via natural infection or through vaccinations

Abbreviations

ACE2
Angiotensin-converting enzyme 2
COVID-19
Coronavirus Disease of 2019
CSF
cerebrospinal fluid
CT
computed tomography
mRNA
messenger ribonucleic acid
PPE
personal protective equipment
RNA
ribonucleic acid
RT-PCR
reverse transcription-polymerase chain reaction
SARS-CoV-2
Severe acute respiratory syndrome coronavirus 2

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Declarations

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Not applicable.

Consent for publication

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Availability of data and material

The authors declare that the data supporting the findings of this study are available within the article.

Competing interest

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Authors' contributions

A.M.A conceived the presented idea and performed the literature review. A.I.A organized the referencing according to the journal requirements, drafted, and critically revised the work.

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