

Review Article

Neurosurgery Practice During the COVID-19 Pandemic



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ABSTRACT

Background and Aim: The viral agent in severe acute respiratory distress syndrome coronavirus 2 (SARS-CoV-2) is the cause of the novel coronavirus disease 2019 (COVID-19). It was first identified in December 2019 in the city of Wuhan, Hubei, China, and the World Health Organization declared it as an outbreak and a Public Health Emergency of International Concern on 30 January 2020, and a pandemic on 11 March 2020. Neurosurgeons are not prime in COVID-19 management but they continue for caring, visiting, and operating neurosurgical patients. In neurosurgical cases that need non-urgent operation, systematic SARS-CoV-2 testing of low-risk patients should be considered. In cases with positive SRAS-COV-2 testing, the procedures should be delayed until they are cured. The high-risk settings in the neurosurgical operation room are endotracheal intubation and extubation, operations in the vicinity of sinuses and/or mastoids, operations with accidental injury to respiratory or digestive tracts, and usage of aerosol-generating instruments on virion-contaminated tissues. The risk of SARS-COV-2 infection is decreased by delaying all nonemergent cases, replacing general anesthesia with other anesthesia methods, replacing neurosurgical approaches with alternative approaches that bypass the respiratory tract, and decreasing the usage of aerosol-generating instruments.

Methods and Materials/Patients: This is a narrative study about COVID-19 infection in neurosurgery. Using the keywords SARS-COV2, neurosurgery, and COVID-19, all the relevant articles (about 52) were retrieved from Google Scholar, Medline, and PubMed and reviewed and critically analyzed.

Results: Neurosurgeons can change neurosurgical routines in COVID-19 patients such as delaying all nonemergent cases, replacing general anesthesia with other anesthesia methods, replacing neurosurgical approaches with alternative approaches that bypass the respiratory tract, decreasing the usage of aerosol-generating instruments, and doing preoperative SRAS-COV-2 testing.

Conclusion: For decreasing the risk of COVID-19 transmission in neurosurgery, we can change routine neurosurgical protocols. Without the prevention of COVID-19 transmission, all neurosurgeons, personnel, and patients will contract COVID-19.

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Highlights

- Because of direct contact during surgery between neurosurgeons and their patients, all neurosurgeons, and the surgical team must be protected from contracting COVID-19.
- In cases that need a non-urgent operation, systematic SARS-CoV-2 testing of low-risk patients (asymptomatic and no history of travel or contact with COVID-19 patients) should be considered. After doing preoperative SARS-CoV-2 testing, in infected patients, if possible, delaying the procedures until they are cured and in negative cases, decreasing the usage of protective equipment should be regarded.
- There is a lower risk of SARS-CoV-2 with :after delaying all nonemergent cases, replacing general anesthesia with other anesthesia methods if possible, replacing neurosurgical approaches with alternative approaches that bypass the respiratory tract, and decreasing the usage of aerosol-generating instruments, including drills, electrocautery, ultrasonic aspirators, lasers, and carbon dioxide insufflators.

Plain Language Summary

For risk reduction of COVID-19, nosocomial infection neurosurgeons can change neurosurgical routines in COVID-19 patients and change high-risk neurosurgical conditions in local nosocomial outbreaks. If we do not consider the prevention of COVID-19 transmission, all neurosurgeons, personnel, and patients will contract COVID-19 and we will lose all of them on the COVID-19 battlefield.

1. Introduction

The novel coronavirus disease 2019 (COVID-19) is a viral infectious disease that has been occurred by the viral agent of the severe acute respiratory distress syndrome coronavirus 2 (SARS-CoV-2), with the presentation of pneumonia in these patients and only 11% of these patients need acute medical care and management. Polymerase chain reaction (PCR) detects the viral RNA and does not mean the presence of intact infectious viral particles. The complete assembled virus is crucial for COVID-19 transmission. Human airway epithelial cells shed this virus and at present, only in secretions of these cells and in feces specimens, the live virus is detected [1, 2], without any evidence of the fully assembled virus in the blood, cerebrospinal fluid (CSF), and central nervous system(CNS) [3-5]. The survival time of SARS-CoV-2 virions out of the body of a contaminated host is about 1.1 h in aerosols, 3.5 h on cardboard, 5.6 h on stainless steel, and 6.8 h on plastic [6]. There are two major routes for SARS-CoV-2 transmission direct and indirect. Direct routes are contact (e.g., kissing an infected individual) or droplets (e.g., inhaling virion-containing aerosols immediately after an infected patient coughed, sneezed, or talked).

Indirect routes are fomites (such as touching a contaminated surface and then touching one's mouth or

nose) or via an airborne transmission (such as aerosolization of virions during medical procedures). At present, respiratory and possibly fecal-oral routes are the main routes of SARS-CoV-2 transmission [7] without any evidence of blood transmission and some reports of transmission from the mother to her fetus during pregnancy [8, 9]. For prevention of these mentioned perioperative nosocomial spreading of SARS-CoV-2, there are different general routines and strategies in most hospitals. Every center has its special strategies against COVID-19 and it is important that all staff be aware of these strategies [10].

Neurosurgeons are not prime in COVID-19 management but they continue caring for critically ill neurosurgical patients [11]. Because of direct contact during surgery between neurosurgeons and their patients, all neurosurgeons and surgical teams must be protected from contracting COVID-19. One of the hypothetical features of SARS-CoV-2 is neurotropism of this virus, which is important from a neurosurgical viewpoint [12, 13]. First of all, SARS-CoV-2 infects the olfactory bulb neurons and then reaches the CNS trans-synaptically. COVID-19 can cause anosmia and dysgeusia even in the absence of other respiratory manifestations [14, 15]. In neurosurgical practice, there are three high-risk conditions in the operation room: during anesthesia for endotracheal intubation and extubation, during surgeries in the vicinity of the sinuses and/or mastoid or injury to respiratory or digestive tracts during operation, and



with the usage of aerosol-generating instruments in viron-contaminated tissues. With consideration of these high-risk conditions, we can optimize our routines, procedures, and approaches and finally decrease the risk of SARS-COV-2 transmission.

2. Methods and Materials/Patients

For evidence acquisition and to provide new information, we concisely reviewed the effects of COVID-19 infection on neurosurgery. Using the keywords of SARS-COV2, Neurosurgery, and COVID-19, all the relevant articles (about 52 articles) since the beginning of COVID-19 were retrieved from Google Scholar, Medline, and PubMed, reviewed, and critically analyzed.

3. Results

While neurosurgeons are not prime in the COVID-19 research, prevention, and management, they can prevent nosocomial transmission and infection of neurosurgical patients and medical personnel. For acquiring this fact, we can change some neurosurgical approaches, procedures, and routines based on our present knowledge of SARS-COV-2 biology and transmission, and consideration of high-risk neurosurgical settings for COVID-19.

4. Discussion

Prevention of perioperative COVID-19 spreading

In most hospitals, there are some general measures for the prevention of pre-operative SARS-COV-2 transmission. One of the most comprehensive reports of such policies comes from a large tertiary hospital in Singapore [16]. Every hospital has its own strategy for the prevention of COVID-19 transmission but for the effectiveness of these strategies, all personnel must be familiar with these strategies. Following general protocols can prevent perioperative nosocomial spreading [16]:

1-Hospital strategies: decreased elective activities, searching for COVID-19 in patients, visitors, and medical personnel, and the presence of effective imparting of information's with personnel

2-Operation room (OR) strategies: We can consider a specific OR and anesthetic personnel for COVID-19 patients, and make a new plan in OR workflows for COVID-19 patients

3-Anesthesia policies: formal training sessions on protective equipment usage, each hospital must have its own personnel without shared personnel, postponement of all elective preoperative visits, and prohibition of visiting and caring for COVID-19 cases by pregnant or immunocompromised personnel

4-Protective equipment: There are three groups of patients and conditions for protective equipment as follows:

-Low-risk patients (asymptomatic and no history of travel or contact with COVID-19 patient): surgical masks and droplet precautions

-High-risk patients and COVID-19 patients: N95 masks, eye protection, gown, and single and/or double gloves

-When performing aerosol-generating procedures on COVID-19 patients, we must use a powered air-purifying respirator

5-Specific strategies: during patient transport, all patients must wear a surgical mask, patients should be transported in a special route for COVID-19 patients to OR or other parts of the hospital, we can consider a special OR for COVID-19 patients and keep it empty as much as possible and every time need drugs and/or equipment, take them to especial OR, preferably preparing single-use equipment for especial OR, not taking charts into the COVID-19 OR, covering all monitors, computers, and machines in plastic wrap, performing the patient review, induction, and recovery within the single OR to limit contamination to a single room, and decreasing the number and movement of personnel in the OR

6-Operation room sterilization after the operation of a patient with COVID-19: all disposable parts of the anesthetic breathing circuit that were in contact with the patient's breathing must be discarded, including the soda lime canister, all contact surfaces must be cleaned with quaternary ammonium chloride disinfectant wipes, for OR disinfection, it must be cleaned with sodium hypochlorite 1000 ppm and then with hydrogen peroxide vaporization or ultraviolet C irradiation, and after each COVID-19 case operation, all staff should shower and change new scrubs

Neurosurgery-related risks of COVID-19

In neurosurgery, the risk of SARS-COV-2 transmission under three following conditions is high and we must optimize our procedures to decrease the risk: during endotracheal intubation and extubation, during opera-

tions in proximity to sinuses and/or mastoid or injury to respiratory and/or digestive tract during operation, and usage of aerosol-generating instruments in virion-contaminated tissues.

Risks Related to Anesthesia Techniques and Procedures

There is a significant risk of respiratory transmission of SARS-COV-2 among healthcare workers with anesthesia techniques and procedures because of airway manipulation. These anesthesia techniques and procedures are endotracheal intubation, tracheotomy, noninvasive ventilation, and manual ventilation before intubation with the greatest risk of transmission with endotracheal intubation [17]. Guidelines for the management of the airway in COVID-19 patients can help anesthesiologists to decrease and/or eliminate this risk as much as possible [18-20]. From a neurosurgical viewpoint, it is better to replace general anesthesia and endotracheal intubation with alternative anesthesia methods and techniques as much as possible. In neurosurgery, for many procedures, we can replace GA with conscious sedation, local anesthesia, and/or spinal anesthesia with the patient wearing a face mask to limit aerosolization in the OR. In the following instances, we can replace general anesthesia: external ventricular drain (EVD) placement, chronic subdural hematoma (CSDH) evacuation [21], carotid endarterectomy [22], and lumbar discectomy or laminectomy [23, 24]. If GA is obligatory, we must decrease the number of personnel, including most neurosurgeons in OR during intubation and extubation. Any anesthesia technique and procedure that may induce cough must be prohibited, like awake fiberoptic intubation [25].

Risks related to neurosurgical procedures

For neurosurgeons, the risk of SARS-COV-2 transmission increases during surgical approaches in the vicinity of the sinuses or mastoids: trans-sphenoidal approaches, trans mastoid approaches, transoral approaches, percutaneous trigeminal rhizotomies as well as craniotomies involving the frontal sinuses, such as bicoronal, bifrontal craniotomies or frontal skull fracture repair. For COVID-19 positive patients or in a local outbreak, all of these approaches, if possible, must be delayed or replaced with alternative following approaches :

-Trans-sphenoidal surgeries: Most of these cases are nonurgent and can be postponed. However, in cases that need an urgent operation, pituitary apoplexy or craniopharyngioma with obstructive hydrocephalus transcranial approach (e.g., pterional) or an alternative strategy (e.g., a cystic craniopharyngioma could be

drained through stereotactic implantation of an Omayra reservoir and treated using intracavitary therapies rather than trans-sphenoidal resection) must be replaced.

-Retro sigmoid craniotomy: Because of the vicinity of this approach to the mastoid, it is better to replace it with translabyrinthine approach for vestibular schwannomas.

-In all conditions, while carrying out craniotomy, avoidance from frontal sinuses or mastoid air cells must be considered, which can be facilitated by the use of neuronavigation. Nonoperative treatment or lumbar drainage can be considered in COVID-19 patients with frontal sinus fractures until the COVID-19 status is negative.

-In patients with trigeminal neuralgia that are resistant to drug therapy, it is better to consider radiosurgery over rhizotomy.

-Transthoracic surgeries in spinal tumors or trauma must be replaced with dorsal approaches.

If the patient's safety or surgical outcome is compromised with changing in surgical policy, we cannot modify surgical strategy and in these circumstances that exposure to the respiratory tract is unavoidable, first of all, the COVID-19-positive patients must be decolonized. For decolonization of these patients, standard chlorhexidine skin preparation, intranasal povidone-iodine preparation (especially in end nasal approaches), and chlorhexidine or hydrogen peroxide mouth rinse have should be used; however, the efficacy of this approach remains unproven. Theoretically, gastrointestinal tract involvement during operation, as a rare esophageal injury with mucosal erosion during the anterior approach to the cervical spine with anterior instrumentation or bowel perforation during ventriculoperitoneal (VP) shunt placement, can increase the risk of SARS-CoV-2 infection. For decreasing the risk of COVID-19 transmission in these conditions, we can do the following measures: first of all, we must prevent these complications during operations and if occur, we must increase precautions for prevention of COVID-19 infection with the increased level of PPE and decontamination, for VP shunt placement, it is better to dissect under direct vision versus blind trocar insertion, and consider endoscopic third ventriculostomy (ETV) in place of VP shunt every time is possible [26, 27].



Risks of usage of the Aerosol-Generating Instruments on Virion-Containing Tissues

Usage of aerosol-generating instruments is the most common but highly theoretical risk for airborne transmission of SARS-COV-2 for neurosurgeons. These aerosol-generating instruments are all powered drills [17, 28, 29], electrocautery [17, 28, 30], lasers [31], ultrasonic aspirators [32] as well as insufflators used for pneumoperitoneum maintenance during laparoscopic surgery [33]. These aerosolized particles if contain complete assembled virions are infectious as definitely occur in the respiratory and digestive tracts. However, there is no conclusive study on the presence of these assembled complete virions in CSF, CNS tissue, and bone, while the clinical significance of aerosolized blood remains uncertain. In about 10% to 40% of COVID-19 patients, SARS-COV-2 RNA can be isolated from the blood [34-37], but this does not mean the presence of complete viral particles. Because of the avoidance of the aerosol-generating instruments, if surgically possible, it is very important to consider the following conditions:

- 1) COVID-19-positive patients
- 2) If there is the local nosocomial spreading of COVID-19 with an unknown source
- 3) During surgical approaches in the vicinity of sinuses or mastoid

In all of these conditions, it is better to use rongeurs and curettes instead of drilling with a burr. Using a Hudson brace or a twist drill instead of a perforator for making burr holes, especially in conditions that a single hole is sufficient, like EVD placement or CSDH, is safer [38-40]. Using rongeurs and chisels in place of high-speed drilling in transphenoidal operation is safer. In spinal decompression and stabilization, we can use various Kerrison punch rongeurs for bony removal instead of drilling, and manual, tactile pedicle probes are suggested to facilitate the placement of pedicle screws. If drilling during operation is obligatory, it must be used at a lower speed and drilling should be stopped during irrigation and large suctions should be used to aspirate as much particulate matter as possible and shield the drilling area with a transparent adhesive film "tent" or gauzes. In spinal operations, for decreasing the usage of drilling navigation, minimally invasive techniques, such as endoscopic procedures and percutaneous screws should be considered. During electrocautery, the smoke must be suctioned as soon as possible. Decreased usage of lasers and ultrasonic aspirators must be considered.

For the prevention of the aerosolization created by the carbon dioxide insufflators, VP shunt operation must be done open rather than laparoscopically [41]. Manipulation of aerosol-generating instruments must be prohibited by learners [36].

Preoperative Sars-Cov-2 testing

In patients without any symptoms and without any history of traveling or contact that operation is obligatory but not urgent, perioperative SARS-COV-2 testing must be considered. In COVID-19, about 17.9% are asymptomatic carriers; however, with this SARS-COV-2 testing, we can detect these persons and significantly reduce the nosocomial spreading and preserve the protective equipment supply [42, 43]. After doing preoperative SARS-COV-2 testing, in infected patients, if possible, delaying the procedures until they are cured and in negative cases, decreasing the usage of protective equipment should be regarded. However, the false sense of certainty with a negative test can paradoxically increase nosocomial transmission and this caution must be considered until COVID-19 tests are standardized and their sensitivity and specificity are known at the local level for interpretation of negative test results. Therefore, in cases with high clinical suspicion of COVID-19 with negative test results, it is better to repeat the COVID-19 PCR assay [44] and secondly, these cases should be considered as infected. In the time interval between the testing and the operation, patients must be asked to take additional precautions (i.e., self-quarantine). At present, immune testing is not yet reliable [45, 46].

Important neurosurgical viewpoints during the COVID-19 pandemic [16, 47]

- Decreasing the number of operations as possible and only operating the patients that cannot postpone their operations
- Using an alternative surgical approach and technique with a lower risk for COVID-19 transmission if possible
- Decreasing the number of personnel in the OR to a minimum level if possible
- It is better not to involve observers, students, and even residents during the operation
- Increasing shifting time and decreasing breaking time to minimize personnel turnover

-It is better not to exchange and move neurosurgeons and personnel between hospitals

-If possible, consider a special neurosurgical team, including neurosurgeons, surgical technicians, and an anesthetic team for COVID-19 patients that will decrease contact with others

-If possible, consider preoperative SARS-CoV-2 testing for all surgical patients

Neurosurgical Procedure Optimization [16, 47]

1- Replacing general anesthesia with awake surgeries with facemask and if intubation is necessary, decrease the number of personnel to a minimum level during induction of anesthesia and for intubation, use neuromuscular blockers to prevent cough.

2- Replacing surgical approaches in proximity to the sinuses and mastoids with alternative approaches if possible. In patients that need operation with exposure of the nasal or oral mucosa, it is better to decolonize them before operation with intranasal povidone-iodine preparation (especially in endonasal approaches) and chlorhexidine or hydrogen peroxide mouth rinse and avoid postoperative nasal endoscopy and nasal sprays if possible.

3- Decreasing the usage of aerosol-generating instruments during the operation as follows:

-it is better to replace drills with rongeurs, curettes, or chisels instead of burrs if possible

-for making burr holes, replace perforator with a twist drill and use a Hudson brace

-in spinal operation, replace burr with rongeurs and use manual, tactile pedicle probes to facilitate the placement of pedicle screws

-Not doing unneeded electrocautery and keep away from lasers usage and ultrasonic aspirators

-it is better to do a VP shunt operation open under direct vision and dissection rather than laparoscopically

-it is better to isolate the surgical field with towels during hammering to decrease aerosolization and irrigate with large volumes at low pressure rather than low volumes at high pressure

4- For drilling, consider the following tips:

-drilling must be done at a lower speed

-when irrigation is done, stop drilling

-for aspiration of all airborne particles, use large powerful suction

-for isolation of the drilling area, use a transparent adherent film, tent, or gauzes

-in spine procedures and operations, decrease drilling as possible by using navigation and considering minimally invasive approaches, such as endoscopic procedures and percutaneous instrumentation

The most controversial aspect of the above items is decreased usage of aerosol-generating instruments because the transmission of a respiratory virus with inhalation of lumbar spine dust is contrary to common sense expectations. Because for the occurrence of this virion-contaminated blood or CSF, the bone dust must be aerosolized, which has never been proven, neither for SARS-CoV-2 nor for SARS-CoV [48].

5. Conclusion

For prevention of COVID-19 transmission, we must change routine neurosurgical protocols without affecting neurosurgical outcomes and harming the neurosurgical patients. High-risk neurosurgical settings must be considered and with correct optimization of these settings, we can decrease the risk of COVID-19 transmission. For more clarification of the COVID-19 role in neurosurgery, more conclusive studies are needed and this narrative study is a starting point for future detailed conclusive studies.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conception and design: Guive Sharifi, Ali Kazeminezhad; Data analysis and interpretation: Guive Sharifi, Navid Kalani, Akbar Kazemi, Ali Kazeminezhad; Drafting



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Conflict of interest

The authors declared no conflict of interest.

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