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Original Article

The Management and Outcomes of Coronavirus Disease 2019 Infection in a Series of Neurosurgical Patients

Farzin Farahbakhsh[1,2], Mohsen Rostami[1,2], Alireza Khoshnevisan[2], Negin Naderian[3], Mohammad Ghorbani[4], Michael G Fehlings[5,6], Vafa Rahimi-Movaghar[2,7,8]

[1]Sports Medicine Research Center, Neuroscience Institute, Tehran University of Medical Sciences, [2]Department of Neurosurgery, Shariati Hospital, Tehran University of Medical Sciences, [3]Department of Neurosurgery, Firoozgar Hospital, Iran University of Medical Sciences, [4]Division of Vascular and Endovascular Neurosurgery, Firoozgar Hospital, Iran University of Medical Sciences, [7]Sina Trauma and Surgery Research Center, Tehran University of Medical Sciences, [8]Brain and Spinal Cord Injury Research Center, Neurosciences Institute, Tehran University of Medical Sciences, Tehran, Iran, [5]Department of Surgery, Division of Neurosurgery, University of Toronto, [6]Krembil Research Institute, University Health Network, Toronto, Ontario, Canada

Address for correspondence:
Prof. Vafa Rahimi-Movaghar, Sina Trauma and Surgery Research Center, Hassan Abad SQ., Imam Khomeini Street, P.O.Box: 11365/3876, Tehran, Iran.
E-mail: v_rahimi@sina.tums.ac.ir

Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic has impacted neurosurgical practice worldwide. In Iran, hospitals have halted their routine activities, and most hospital beds have been assigned to COVID-19 patients. Here, we share our experience with 10 neurosurgical cases with confirmed COVID-19. **Materials and Methods:** From February 24, 2020 to April 20, 2020, we were able to obtain clinical data on ten neurosurgical patients with COVID-19 through a predefined electronic form. **Results:** Of the 10 patients with COVID-19 on neurosurgical units, eight underwent surgical interventions. The age of the patients ranged from 21 to 75 years and 70% were males. The diagnosis of COVID-19 was based on chest imaging findings and reverse transcriptase-polymerase chain reaction for coronavirus and an infectious disease specialist and a pulmonologist confirmed the diagnoses. In two cases, there was a significant decrease in O2 saturation intraoperatively. Three patients in this series died during the assessment period. One death was due to respiratory failure induced by the coronavirus infection. The cause of death in other two patients was cardiovascular failure not related to COVID-19. **Conclusions:** We hope we can provide a reference for future studies and help develop a clearer understanding of neurosurgical practice and outcomes in patients with COVID-19. In the time of COVID-19 pandemic when dealing with neurosurgical emergencies, a conservative approach is recommended. Using committed personal protective equipment, short-time operating procedures or minimally invasive surgery must be considered in the management of emergent patients. Resuming elective surgeries need defining measures needed to ensure patients and health-care providers' safety. Reorganizing the health-care system for telemonitoring released patients can lessen hospital visits.

Keywords: *Coronavirus, coronavirus disease 2019, neurosurgery*

Introduction

A new disease which started with pneumonia-like symptoms in December of 2019 in Wuhan China, soon started to impact the whole world.[1-4] Coronavirus disease 2019 (COVID-19) has now spread to most countries and territories, with confirmed 2,995,758 cases and 204,987 deaths according to the WHO situation report of April 29, 2020.[5] Iran with 92,584 confirmed cases and 5877 deaths has been substantially affected by the disease.[5] The disease is particularly pressing in hospitals and health-care facilities. According to the national health system recommendations, hospitals halted their routine activities and most hospital beds have been assigned to COVID-19 patients.[6]

COVID-19 epidemic is still ongoing with a number of cases rapidly rising all over the world. Given predictions related to the anticipated spread of COVID19, we should be ready to provide care for neurosurgical patients while the epidemic is ongoing.[7] Here, we share our experience with 10 neurosurgical cases with confirmed COVID-19.

Materials and Methods

Study population

Surgeons from eight referral neurosurgical departments in Tehran, Iran, were asked to fill a predefined electronic form containing information regarding neurosurgical patients who were diagnosed with COVID-19. First, they all agreed to fill the form, and the total number of eligible cases was calculated to be 24, but only two centers completed the form by the time the deadline was reached on April 20, 2020.

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We identified 10 adults from two hospitals (Shariati Hospital, Tehran University of Medical Sciences and Firoozgar General Hospital, Iran University of Medical Sciences) who needed neurosurgical care and was diagnosed with COVID-19. The diagnosis of COVID-19 was based on chest imaging findings and reverse transcriptase-polymerase chain reaction of a nasopharyngeal swab for coronavirus and an infectious disease specialist and a pulmonologist confirmed the diagnoses. Using a predefined electronic form demographic data, clinical signs and symptoms, type of neurosurgical care, lab and radiologic data were obtained. Furthermore, one of the residents from each department completed the form for patients' coexisting conditions. We did not get informed consent, and this was waved by ethics review boards of both centers, and researchers only collected anonymized data.

Statistical analysis

The electronic form automatically generated a spreadsheet which was then used for analyzing the data in the Microsoft Excel 2019. We are reporting descriptive statistics as medians and interquartile ranges and categorical variables as count and percentage.

Results

Patients characteristics

COVID-19 was first diagnosed on February 24, 2020, in these two hospitals. During the period from February 24, 2020, to April 15, 2020, ten patients in these two hospitals were diagnosed with COVID-19. Table 1 shows the patients' characteristics. In Shariati hospital, one patient was scheduled for surgery before elective surgeries were halted and during the surgery, she developed a decline in O2 saturation and shortness of breath after she was extubated. In Firoozgar hospital, one patient who had been under intensive care unit (ICU) care for a long time was diagnosed with COVID-19. Only one patient was admitted to hospital for respiratory symptoms and several days after admission, she developed neurological symptoms and was consulted for surgery. All other patients came to the hospital with either traumatic events or neurosurgical symptoms. The age of the patients ranged from 21 to 75 years and 70% were males. Before the diagnosis of COVID-19 cough and shortness of breath were most common symptoms. Table 2 summarizes the laboratory data and imaging findings of the patients. Abnormalities on chest radiography or computed tomography (CT) were found in all patients.

Treatment and outcomes

Of 10 patients, eight underwent neurosurgical interventions in this period and one patient had the previous craniotomy and was cared for in ICU for about a month before he was diagnosed with COVID-19 [Table 3]. Surgeons did not report any unexpected complications during their surgeries except in two cases there was an unusual decrease in O2 saturation during the operation. In one of these patients, who did not have any respiratory complaints before surgery, this finding led to the diagnosis of COVID-19. Three patients in this series died during this period. Only one death could be directly related to respiratory infection by coronavirus. This case was the same patient who was in ICU for a long time and even before COVID-19 was suffering from respiratory problems. The cause of death in the other two patients was a cardiovascular origin not related to COVID-19.

Table 1: Clinical characteristic of neurosurgical cases with confirmed coronavirus disease-2019 (*n*=10)

Admission	*n* (%)
Long-term previous ICU admission	1 (10)
Emergency department	7 (70)
Consultation	1 (10)
Elective	1 (10)
Age (year), median (IQR)	58 (34.75-71)
Sex	
Male	7 (70)
Female	3 (30)
Coexisting disorder	
Diabetes	3 (30)
Hypertension	5 (50)
Ischemic heart disease	1 (10)
AML	1 (10)
Respiratory symptoms	
Cough	8 (80)
Shortness of breath	7 (70)
Sputum production	1 (10)
Systemic symptoms	
Headache	8 (80)
Myalgia	2 (20)
History of travel and contacts	
Travel to country or states with a high number of COVID-19 cases	0 (0)
Contact with people with symptoms of respiratory disease	4 (40)
Neurosurgical symptoms	
Confusion	4 (40)
Loss of consciousness	3 (30)
Paresthesia of lower limbs	1 (10)
Penetrating foreign body in the brain	1 (10)
Cranial nerve palsy	1 (10)
Imaging	
Chest radiography	9 (90)
Chest computed tomography	10 (100)
Temperature before the diagnosis of COVID-19	
≥38°	5 (50)
<38°	5 (50)

IQR – Interquartile range; COVID-19 – Coronavirus disease 2019; AML – Acute myeloid leukemia

Discussion

In this case series, we present a series of 10 patients admitted to neurosurgical units with a concurrent

Table 2: Imaging findings and laboratory data of neurosurgical cases with confirmed coronavirus disease-2019 (*n*=10)

First laboratory results after diagnosis of COVID-19	*n* (%)
White-cell count	
Median (IQR)	11,120 (8249-19,100)
≥10,000/mm^3, *n* (%)	6 (60)
<4000/mm^3, *n* (%)	0 (0)
Lymphocyte count	
Median (IQR)	1864 (1470-3350)
<1500/mm^3 - No.(%)	3 (30)
CRP	
Quantitative (*n*=6) (normal reference range 0-6)	
Median (IQR) -mg/L	75 (30.5-79)
Qualitative (*n*=4)	
Positive	3 (75)
Negative	1 (25)
Infection analyses other than COVID-19 - number of positive/number of total worked up patients	
Blood cultures	0/5
Septum cultures	2/9
Chest radiography findings - number of positive/number of total (%)	
Clear	2/9 (22.2)
Bilateral infiltration	5/9 (55.5)
Unilateral infiltration	2/9 (22.2)
Pleural effusion	0/9 (0)
Computed tomography findings - number of positive/number of total (%)	
Bilateral ground glass	8/10 (80)
Nodules	0/10 (0)
Pleural effusion	2/10 (20)

IQR – Interquartile range; CRP – C-reactive protein; COVID-19 – Coronavirus disease 2019

Table 3: Treatments and clinical outcomes of neurosurgical cases with confirmed coronavirus disease-19 (*n*=10)

Neurosurgical treatment	*n* (%)
Craniotomy/craniectomy	5 (50)
Endoscopic endonasal tumor resection	1 (10)
Conservative management	2 (20)
Angiographic coil embolization	1 (10)
Laminectomy	1 (10)
Unexpected events during surgery	
Respiratory disturbances	2 (25)
Therapy for COVID-19	
Hydroxychloroquine	8 (80)
Oseltamivir	5 (50)
Loponavir/ritonavir	3 (30)
O2 therapy	8 (80)
Length of stay days, median (IQR)	
In hospital (non-ICU)	7 (0.2-10.5)
In ICU	3.5 (1.2-11.5)
In hospital, survivors (non-ICU)	7 (4-10)
In ICU, survivors	2 (0.5-6)
Outcome	
Discharge	5 (50)
In hospital	2 (20)
Hospital mortality	3 (30)

COVID-19 – Coronavirus disease 2019; ICU – Intensive care unit

diagnosis of COVID-19. There were two patients who were already admitted in these two centers when the coronavirus pandemic started. One patient was scheduled for elective surgery and during and after surgery, she developed respiratory symptoms. The other one was a patient who was in ICU for a long time and COVID-19 led to worsening of his respiratory symptoms. It's possible that these two patients were infected with the disease by nosocomial transmission. Nosocomial transmission of COVID-19 is a major concern in hospitals which can lead to super spreading of the virus in the hospitals.[8] Infection prevention and control (IPC) measures, which can impact within hospital spread of the disease, must be taken seriously. Previously in the 2003 severe acute respiratory syndrome (SARS)-CoV outbreak, it has been shown that adhering to IPC measures was related to within hospital transmission of the disease.[9-12]

Health-care workers rely on personal protective equipment (PPE), such as gloves, face masks, goggles, face shields, respirators, and gowns, to prevent spread of infection. At first, our hospitals were not equipped with protective gear that staff needed for facing coronavirus patients. PPE were scarce and many doctors and staff used unconventional solutions for PPE. With soaring numbers coronavirus cases, doctors and other staff were confronting

a shortage of PPE. Surgical mask and nonsterile gloves which was readily available in the operation rooms and wards could not be easily found in the hospital. This shortage is now resolving in our centers. Before an operation on a patient with definitive coronavirus infection or those who were suspected by an infectious disease specialist to have the virus, N95 respirator masks and a hazmat suit (hazardous materials suit), also known as decontamination suit, which is a piece of PPE that consists of an impermeable whole-body garment worn as protection against hazardous materials. Due to these suits being so warm, we could not perform long neurosurgical procedures wearing them, so for the surgery itself we used our regular surgical gowns, N95 respirator masks, and goggles or face shields.

It seems that the disease and what came with it has put a lot of psychological pressure on health care workers. Neurosurgeons are not an exception in this regard. Facing increasing contact with cases, shortage of PPE, lack of definitive treatment, fear of infecting our families, lack of adequate support and increasing internet and media coverage maybe some of the sources of this psychological burden. This was true for the 2003 SARS-CoV outbreak and new data from China also supports the idea of increasing psychological burden.[13-17]

COVID-19 has now spread all around the globe. There is no suggestion that disease might disappear soon. It is also possible that this virus become another virus that people face regularly.[18] Still, it is not clear how COVID-19 impacts course of surgeries. In our patients, we did not encounter any unexpected events during the surgery itself. There was a problem with ventilation in two of our patients during the surgery. Some of our patients had signs and symptoms of the disease before the operation but some developed symptoms after the operation. Other reports suggest high mortality in surgeries performed for patients with COVID-19.[19,20] Meanwhile, we must consider that the virus might suppress immune system[21,22] and surgery might ignite the infection.

In our series, three patients died. This group consisted of two patients with severe traumatic brain injuries and a patient with a rapidly growing recurrent brain neoplasm (the last pathology was glioblastoma multiform; WHO Grade IV). All these three patients were admitted to the hospital with loss of consciousness due to severe brain damage. Two of them had traumatic events that led to intracerebral hemorrhage and subarachnoid hemorrhage with severe brain edema. All these three patients had a GCS lower than 8 when they were admitted. They all developed bilateral ground-glass infiltration in their chest CT scan, and pleural effusion emerged in one of them which led to clinical suspicion of COVID-19. This suggests that patients with severe brain damage due to neoplastic or traumatic events might at higher risk for unfavorable outcomes with COVID-19. These three patients had poor prognosis even if they were not infected with coronavirus and our series only consists of 10 patients, so no definitive assumptions can be made.

COVID-19 cases are still on rise around the world. We still do not know how it might change neurosurgical practice in long term. There are some studies sharing their experiences and recommendations for neurosurgical practice.[23-26] However, they mostly focus on practice recommendations not patients outcomes. We are still following the patients to unfold the long-term outcome of neurosurgical patients with COVID-19. If this pandemic becomes chronic, it is better to think of ways to start modified neurosurgical practice despite COVID-19 and even develop specific guidelines for neurosurgical practice in the presence of virus. Other series on outcome of neurosurgical patients infected with coronavirus can help us have a better assessment and strategic planning for the situation.

To outline the lessons learned and recommendations for neurosurgical units, safeguarding a very skilled health-care staff is the highest priority for any society and health-care system.[27] According to high positive screening for COVID-19, precaution is suggested in all patients. Nearly, all COVID-19-infected patients had clinical signs and symptoms and diagnosis of pneumonia and had distinctive CT imaging patterns. Therefore, a chest X-ray/chest CT scan is essential in early diagnosis and evaluation of disease course. Therefore, the chest X-ray/CT scan is recommended for the clinical diagnosis of COVID-19 in neurosurgery units.[28] In addition, any time in the process of hospitalization, whenever we see any fever or any respiratory distress or repeated cough, neurosurgery staff, residents, and professors would consider possible COVID-19 and re-evaluation performance. The availability of intensive care beds, ventilators, and all protective equipment is suggested.[29]

COVID-19 has shown a rapid spread. It is cautious to limit nonemergency neurosurgical procedures and prioritize urgent neurosurgical treatment. When dealing with neurosurgical emergencies, a conservative approach is recommended. When working on COVID-19 patients, using committed PPE and obeying to specific rules is suggested. Short-time operating procedures or minimally invasive surgery must be considered in the management of emergent patients. The rules outline the rigorous supervision of entry/exit into emergency room, neurosurgery department, clinics, and operating room and guidance on performing practices safely to lessen risk spreading the virus. The reorganization of all personnel and health system based on the numbers needed to function and quality of job is necessary.[30] Triage for probable COVID-19 symptoms is recommended both before hospitalization by telephone at home and at the time of hospitalization. During hospital stay, the reorganized

team of education should instruct patients as much as possible to accelerate their return home. Patients must be discharged under steady good quality conditions to reduce the risk of readmission. It is wise to reduce or postpone postdischarge controls and reorganize the health-care system for a sufficient communication for telemonitoring released patients to lessen hospital visits.[31] Finally, the medical and surgical management of patients with any neurosurgical disease must be adapted by adjusting the consultation methods, by arranging interventions according to the prognosis of disease, taking into checking account the patient's comorbidities.[32] Right now, many countries are planning to resume their routine activities. The greatest concern when resuming full clinical care is continuation of social distancing, have mask and glove, and cannot be so sympathetic with our patients as before.

Elective surgeries can't be postponed for long in neurosurgical patients and if this pandemic lasts longer many of surgeries marked as elective should be resumed. We are worried that delays in care might result in substantial burden on both patients and health systems. Many are tolerating pain and disabilities before they can get the treatment they need. Elective surgeries can only be resumed after a roadmap is prepared. We should keep in mind that this pandemic is no where near the end. Therefore, it is better to design measures to ensure patients and health-care providers safety. If there are enough COVID-19 tests available, routing testing of elective patients less than 48 h before the procedure is suggested. If the test is positive, possibility of delaying surgery for at least 2 weeks must be discussed between surgery team and the patient. If a patient is negative for COVID-19, surgery, pre- and post-operative care can be performed as usual. It is possible that even patients with negative tests for COVID-19, found to be positive during their admission. In these cases, if delaying surgery is not recommended, all staff in contact with the patient must have appropriate PPE. It is better that the patient wears a mask at all times in his/her stay at the hospital. If the procedure is performed, the surgical room must remain empty for certain time to allow air exchange. All equipment and supplies should be cleaned per protocol. Based on patients' postoperative condition, they must be transported to an individual ward room or isolated ICU bed for postoperative care. It is better to monitor employees who were in contact with the patient for COVID-19 sign and symptoms and if possible, they should not return to patient care unless asymptomatic for 72 h.

There are some limitations in our study. In this series, no autopsy was done on three deceased patients to define the cause of death. We also could not collect all eligible 24 patients in these eight hospitals. We hope that long-term follow-up of these patients and other published cases with similar condition help make COVID-19 situation in neurosurgical practice clearer.

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Conflicts of interest

There are no conflicts of interest.

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