

Short Communication

Perioperative management strategy of severe traumatic brain injury during the outbreak of COVID-19

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ABSTRACT

Since December 2019, a pneumonia caused by a new coronavirus, i.e. COVID-19 occurred in Wuhan, Hubei Province, China. Although the epidemic in China has been brought under control, the global COVID-19 situation is still grim. Severe traumatic brain injury (TBI), as one of critical conditions in the department of neurosurgery, requires an early and effective treatment, especially surgery. There were currently no reliable guidelines on how to perform perioperative protection in TBI patients with suspected or confirmed coronavirus infection. According to the corresponding treatment regulations and guidelines issued by the authorities, we summarized the management strategy of TBI patients in perioperative period during the COVID-19 outbreak based on medical and nursing practice, in order to provide a reference for clinicians.

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Introduction

In December 2019, a pneumonia caused by unknown factors occurred in Wuhan, Hubei Province, and later the disease has been defined as COVID-19.^{1,2} A respiratory illness that was caused by the coronavirus, 2019-nCoV, was transmitted mainly by contact with infectious material (such as respiratory droplets), and was characterized especially by fever, cough, and shortness of breath and may progress to pneumonia and respiratory failure.

During the epidemic period, the incidence of traffic injuries and assaults have declined, but falling, mostly in elderly people, was the main cause of severe traumatic brain injury (TBI). Elderly patients probably have some comorbidities and poor resistance, presenting conscious disorders, physical disturbance, vomiting and aspiration after TBI, and even some life-threatening symptoms, so they require emergency rescue, surgery in particular. Intracranial hypertension causes vomiting, and the vomitus can be aspirated into lungs, leading to pneumonia, which was difficult to be distinguished from COVID-19. From January 25, 2020 to February 25, 2020, 8 TBI patients with suspected or confirmed COVID-19 underwent surgeries in our hospital. According to the corresponding treatment regulations and guidelines issued by the authorities, we

summarized the management strategy of TBI patients in perioperative period during the COVID-19 outbreak based on our medical treatment and nursing practice, in order to provide a reference for clinicians.

Preoperative preparation

Screening (level II or III protection)

Screening for COVID-19 before surgery was essential. Patients with TBI were often accompanied by disorder of consciousness, so the doctors should quickly and completely collect epidemiological history from their family members. Pharyngeal swabs were collected in patients requiring emergency surgery, and secretions of the lower respiratory tract were collected by tracheal intubation for polymerase chain reaction (PCR) testing of coronavirus. Preoperative examinations include blood routine, C-reactive protein, and procalcitonin determination. Brain computed tomography (CT) and chest CT should be performed as soon as possible to exclude multiple injuries.

Because the examination of nucleic acid test needs a long time, chest CT was particularly important.³ The patients with positive CT findings but 2019-nCoV negative in nucleic acid test account for 30%–40%,⁴ so chest CT was essential in COVID-19 screening. The patients with positive CT findings or clinical manifestations such as fever and cough should be treated as suspected cases until COVID-19 risk was excluded. The patients with pneumonia caused by

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vomitus aspiration should be distinguished from the patients with COVID-19. If necessary, consultation with doctors from respiratory and radiology departments (Fig. 1) is recommended. Even we could use the internet video, telephone and other ways to request experts and more advanced hospitals for consultation.

The doctors should pay attention to the details of screening. The traditional method of one-on-one inquiry from symptoms to case history was not recommended. Special attention should be paid to patients traveled in epidemic areas or contacted with high-risk patients when collecting personal history. Multidisciplinary team including respiratory, radiology and neurosurgery doctors should be organized for patient admission. The patients with epidemiological history but negative chest CT findings should be treated with caution in accordance with the management principles of COVID-19. For the patients with abnormal chest CT findings but no epidemic contact, the cooperation with radiology doctors was needed to determine whether the patient was highly suspected, suspected, or excluded from COVID-19. For the diagnosis of TBI, the type and volume of intracranial hemorrhage should be identified immediately. For suspected multiple injuries, immediate consultation with relevant departments was necessary to provide more diagnostic information for surgery.

Protection of medical providers is important throughout the whole process during COVID-19 outbreak. General medical staff should take level I protection, those who contact with the patients should take level II protection, and the staff in charge of collecting

throat swabs or lower respiratory tract specimens should take level III protection. After contact with the patients, hand hygiene and object disinfection should be performed with 75% ethanol, chlorine-containing disinfectant, peroxyacetic acid, etc.

Transfer (level II protection)

For suspected or confirmed cases, special transportation tools (beds, stretchers, wheelchairs, etc.) were used to send them to an isolation ward or directly to operating rooms through a special transfer channel. The transfer channels were closed after disinfection. Medical personnel involved in the transfer should take level II protection.

Attention should be paid on the details of the transfer after admission. Disposable sheets and quilts were used in patient transfer, and the sheets were put into a special plastic bag as medical waste after use. To prevent cross-infection, the trolley (including bedding) should be re-sterilized after delivering the patient to the ward. The transportation instruments should be disinfected strictly. If the patients vomited or coughed sputum up on their way to the laboratory and radiology departments, disinfection should be performed immediately. Meanwhile their accompanying relatives should be disinfected as suspected cases of COVID-19. If necessary, it was recommended that the family members who contacted with the patients go to the fever clinic for testing.

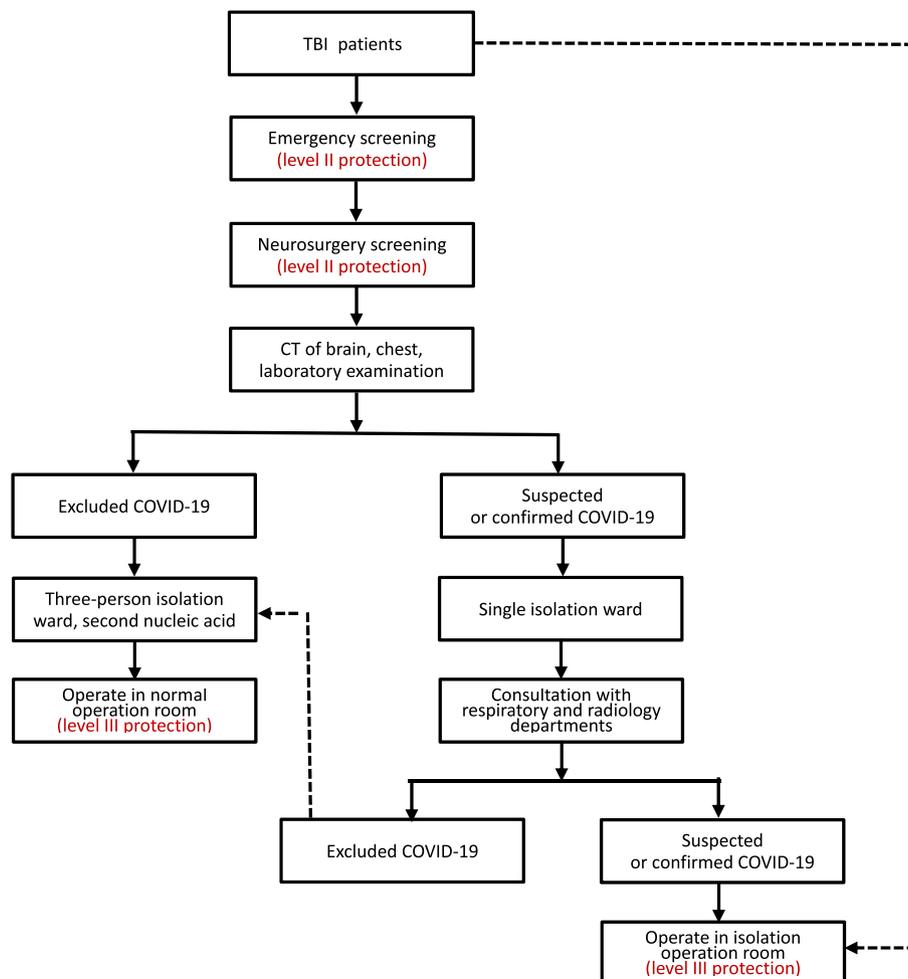


Fig. 1. Emergency screening process for patients with severe traumatic brain injury.

Operating room preparation

For confirmed or suspected cases of COVID-19, an isolation operating room should be used. A dedicated negative pressure operating room (−5 Pa) with separation of contaminated area, buffer area, and clean area was recommended. If not, an operating room with independent purification and relatively independent space can be used. The isolation operating room should have separate channels for entry and exit, and a separate transfer channel to the related departments, which should be closed after disinfection. Medical staff in charge of transfer should take level II protection. The rescue equipment and materials should be prepared during the transportation.

Before the operation, the anesthesiologist, circulating nurse, instrument nurse, and surgeon should communicate with each other about the patient's information and report it to the hospital infection control department. According to the needs of the operation, the instruments, surgical dressings, and drugs should be prepared as adequate as possible to avoid or reduce the frequency of opening the door during the operation. Surgical staff cannot leave the operating room during the operation. The sign of "COVID-19 Patients in Operation, Staff Only" was hung at the door of the operating room to indicate that visitors were not allowed inside. The protective equipment should be labeled, including N95 masks, surgical masks, sterile caps, positive pressure headgears, goggles, protective screens, protective clothing, one-piece isolation gowns, disposable surgical gowns, sterile gloves, long boots. The wearing tips were given, e.g., antifog agent should be applied before surgery because water vapor will blur the vision of the surgeon after wearing goggles for a long time.

The details of preoperative preparation included following suggestions. (1) Surgeon should timely communicate with the anesthesiologist and nurses on the patients' basic situation, such as comorbidities or special requirements by phone. (2) For invasive arterial puncture, central venous catheterization, nerve block and spinal anesthesia, the anesthesiologist should have enough time for patient rescue. If a ventilator was used, breathing filters were needed for the inlet and outlet of the ventilator and artificial nose need to be used on patient.

Surgery

Protection of surgical staff (level III protection)

Coronavirus spreads mainly through droplets. Most of the traumatic brain surgeries require general anesthesia. A large amount of aerosol may be generated during tracheal intubation, non-invasive ventilation, sputum extraction, extubation and intraoperative use of electric knife. Moreover, the narrow space and closed environment of the operating room increased the risk of infection. Therefore, the number of surgical staff including anesthesiologists, nurses and surgeons should be reduced and all take level III protection. Disposable surgical bag (large-hole sheet, surgical gown, treatment towel), syringe, infusion set, blood transfusion set, gloves, masks, and caps that were used in the surgery need to be destroyed as medical waste after surgery.

The equipment for level III protection of a surgeon included N95 masks, surgical masks, double-layer sterile caps, goggles, inner protective clothing, outer coveralls, and two layers of gloves (outer layer was sterile surgical gloves). Besides, after hand washing, the surgeon should wear a surgical gown and the third layer of sterile surgical gloves. It was revealed that doctors were not under high risk of infection during the operation if they wore appropriate protective equipments.⁵

Anesthesia management

For suspected or confirmed COVID-19 patients, during the anesthesia induction, the anesthesiologist should avoid increasing airway pressure and causing lung damage which may be easy to spread virus. Low tidal volume and high frequency ventilation was given when the patient was unconscious. Deep sedation with whole-vein induction before tracheal intubation and use of visual laryngoscope for tracheal intubation after muscle relaxation could improve the success rate and avoid irritative cough. It was recommended that 2 doctors to perform intratracheal intubation, i.e. one performing long-distance endotracheal intubation with help of the other one.

The details of anesthesia management included following. The patient's mask should be discarded in accordance with the infection control requirements. Before general anesthesia, the patient should be fully pre-oxygenated while wearing a mask. The tracheal intubation was performed after muscles were fully relaxed. Fast-acting muscle relaxants such as rocuronium bromide were recommended to prevent coughing during intubation. During the operation, the vital signs were closely monitored. It was suggested to pay more attention to blood pressure after the decline of intracranial pressure. In order to maintain the deep sedation of anesthesia, extubation was not indispensable after surgery. The patient was recommended to be transferred to neurosurgical intensive care unit (NSICU) for further treatment.

Principles of surgery

Patients with TBI need to be treated as quickly and effectively as possible, and thus most patients were operated before receiving results of coronavirus PCR test. Therefore protection of both medical staff and patients is equally important, so the strategy of TBI surgery needs to be adjusted during the epidemic period.

It was recommended that the surgery be performed by an experienced surgeon. The common technique—decompressive craniectomy and intracranial pressure monitoring were applied to simplify the steps and shorten the operation time (within 120 min). The operation should be careful and gentle to avoid the splashing of debris, blood and body fluids. The hemostasis should be thorough and adequate to prevent bleeding from spreading to the surroundings along the skin incision. The irrigation and drainage during surgery was reduced to avoid the spraying or splashing of blood and body fluids.

The surgeons in level III protection may encounter other difficulties, such as increased sweating for long-time surgery, unclear vision of protective goggles caused by vapor, and reduced hand sensation for wearing multilayer gloves. Therefore, it was recommended to prepare antifog agents before surgery, apply damage-control surgery, and shorten the operation time.

During the operation, besides the blood, secretions and excreta of the patient, special attention should be paid to aerosol produced in tracheal intubation, sputum suction and use of other electro-surgical equipment. In spite of gravity, aerosol can suspend in air for a long time, and invade the human body through the respiratory tract. During the operation, the surgical staff should cooperate with each other to avoid secondary injury and infection.

Postoperative protection

Disinfection of medical staff and operating room, collection of pathological specimens

After leaving the operating room, the medical staff firstly remove sterile gloves and surgical gowns, disinfect their hands, and

Table 1
Clinical characteristics of 8 traumatic brain injury patients underwent surgery with suspected or confirmed COVID-19.

| Case | Gender/age (year) | GCS at admission | Type of hematoma | Surgical styles | Time of surgery (min) | COVID-19 | Infection of medical staff |
|------|-------------------|------------------|------------------|-----------------|-----------------------|-----------|----------------------------|
| 1 | Male/61 | 6 | SDH | EH+DC | 116 | suspected | None |
| 2 | Male/54 | 6 | SDH+SAH | EH+DC | 94 | suspected | None |
| 3 | Female/74 | 4 | SDH+IH | EH+DC | 106 | confirmed | None |
| 4 | Male/81 | 7 | EDH | EH | 80 | suspected | None |
| 5 | Male/76 | 9 | SDH+SAH | EH+DC | 114 | suspected | None |
| 6 | Female/69 | 9 | SDH | EH+DC | 94 | suspected | None |
| 7 | Male/51 | 7 | EDH | EH+DC | 106 | suspected | None |
| 8 | Female/59 | 8 | SDH+IH | EH+DC | 114 | suspected | None |

GCS: Glasgow coma scale, EDH: epidural hematoma, SDH: subdural hematoma, SAH: subarachnoid hemorrhage, IH: intracerebral hematoma, EH: evacuation of hematoma, DC: decompressive craniectomy.

then remove the isolation gown, outer cap, surgical mask, and protective clothing, goggles, inner cap, and N95 mask in order. Put the removed objects in a special container, disinfect their hands again, take a bath, and then leave the operating room. Surgical personnel who wear level III protective equipment, complete the operation smoothly, and perform standardized procedures of removal and decontamination without accidental exposure can be exempted from quarantine. If there is any abnormality during observation period, they should seek for medical treatment as soon as possible.

As a high-risk area, the operating room should be thoroughly disinfected. The floor was disinfected with 5000 mg/L chlorine-containing disinfectant for 30 min; the surface of the instrument table and anesthetic instruments was wiped with 2000 mg/L chlorine-containing disinfectant. Blood stains, secretions and other pollutants should be treated with 5000 mg/L chlorine-containing disinfectant before cleaning. In addition, we should pay attention to the disinfection of air conditioning and ventilation system, and routinely sterilize the exhaust outlets and air outlets after surgery. For a standard negative-pressure operating room equipped with all fresh air conditioning, only the high-efficiency filter at the exhaust port needs to be replaced after operation, and the air-conditioning purification system maintained a negative pressure state for at least 30 min.

Research have shown that angiotensin-converting enzyme II receptors, which were highly expressed in abnormal blood vessels of pathological specimens, play an important role in mediating coronavirus infection.⁶ Effective protective measures should be taken in processing surgically-removed specimens. The specimens were preserved in organic formaldehyde as soon as possible and organic solvent formaldehyde can effectively eliminate coronavirus.⁷ Specimens were specially registered, and specimen bags and transfer boxes were marked with warning signs. After being in buffer area, the specimens were sent for pathological examination. Physicians should take level III protection for handling specimens, and level II protection for sending specimens.

The details of postoperative protection should be paid attention to. Alcohol-containing or hydrogen peroxide-containing disinfectants were recommended, but chlorhexidine hand products were not recommended. After operation, instruments were sealed in place, fastened with a double-layered yellow medical waste bag, labeled as "COVID-19", and placed separately. Medical supply center needs to be called to collect them in time for subsequent disinfection.

Transfer (level III protection)

Postoperative transfer needs stricter isolation and protection than preoperative transfer, because most patients with TBI have not been extubated or weaned after surgery. During the transportation

back to the ward, a simple respirator was needed to assist breathing, so the pipeline may fall off because of cough, causing contamination of the channel. Medical staff in charge of transfer should be equipped with level III protection, and the transfer channel should be closed after disinfection.

Visitor management

The patient was admitted to an isolation ward of NSICU for vital sign monitoring and supportive treatment. The medical staff in the isolation ward should take level III protection. The patient's immediate family members were required to sign COVID-19 epidemiological informed consent. Family members with close contact with the patient can be informed by telephone and the communication content should be recorded. For patients without any company, the cases should be reported to the hospital medical department for routine records.

During the epidemic period, all visits were forbidden. The patient's family members were advised to contact the doctor by telephone or online at a prescribed time to know the patient's condition, treatment and prognosis. If necessary, family members were allowed into the doctors' office for face-to-face communication after getting permission. No gathering of patients and their family members was allowed in hospital.

Clinical characteristics of the eight TBI patients

Clinical characteristics of 8 TBI patients were summarized in Table 1. There were 5 male patients and 3 female patients. The mean age of patients was 65.6 years. Subdural hemorrhage was found in 6 patients, and 7 patients underwent surgery of evacuation of hematoma and decompressive craniectomy. The mean time of surgery was 103 min. Among 8 patients, only 1 elderly female patient was eventually diagnosed as COVID-19, unfortunately, the patient died on the 3rd day due to severe injury. During perioperative period, no medical staff were infected with COVID-19.

Conclusion

The epidemiological characteristics and clinical manifestations of COVID-19 have not been fully understood yet. As one of critical neurological diseases, early and effective treatment is important for TBI patients. Emergency surgery under unclear diagnosis of COVID-19 was a challenge for psychological and professional capacities of medical staff. How to protect both medical staff and the patient was our major concern. Based on the clinical practice of 8 cases of TBI combined with suspected or confirmed COVID-19, we summarized the following points. (1) Preoperative screening was crucial. In the absence of PCR results of coronavirus, it was important to identify pneumonia caused by vomiting and aspiration or COVID-19.

Multidisciplinary consultation was recommended. Preoperative preparation for surgery should be adequate to avoid opening the door of the operating room during the operation. The protective measures, such as antifog agent for goggles, were necessary. (2) Surgical personnel should take level III protection. Adequate sedation and muscle relaxation were given to reduce time of tracheal intubation. Optimal surgical scheme, proficiency surgical skill, reduced surgical steps on the principle of damage control surgery and shortening of operation time were also important. (3) After surgery, medical staff should wash and disinfect themselves, the operating room was sterilized and the specimen was preserved in formaldehyde as soon as possible. Postoperative transportation was under level III protection to prevent patients from cough and pipelines from falling off. The PCR test of coronavirus was conducted after surgery. All visits were forbidden during the epidemic period, and the family members were recommended to contact the doctor by phone or online.

Treatment of TBI patients during the COVID-19 epidemic period put forward higher requirements on medical staff's clinical experience, theoretical knowledge, and professional skill. Effective perioperative management of patients with TBI will lead to a positive impact on the patient's recovery and prognosis, improving patient satisfaction of medical services.

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Ethical Statement

The study was approved by Chongqing Emergency Medical Center Ethical Review Board (No. 18, 2020).

Declaration of Competing Interest

There was no conflict of interest declared.

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