



■ GENERAL ORTHOPAEDICS

Spinal surgery and related management on patients with COVID-19: experience of a regional medical centre in Wuhan

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During the pandemic of COVID-19, some patients with COVID-19 may need emergency surgeries. As spine surgeons, it is our responsibility to ensure appropriate treatment to the patients with COVID-19 and spinal diseases. A protocol for spinal surgery and related management on patients with COVID-19 has been reviewed. Patient preparation for emergency surgeries, indications, and contraindications of emergency surgeries, operating room preparation, infection control precautions and personal protective equipments (PPE), anaesthesia management, intraoperative procedures, postoperative management, medical waste disposal, and surveillance of healthcare workers were reviewed. It should be safe for surgeons with PPE of protection level 2 to perform spinal surgeries on patients with COVID-19. Standardized and careful surgical procedures should be necessary to reduce the exposure to COVID-19.

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Introduction

In December, 2019, a cluster of cases of pneumonia with unknown aetiology was reported in Wuhan, People's Republic of China.^{1–3} On 7 January 2020, a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was identified as the causative organism of these patients.⁴ Coronavirus disease 2019 (COVID-19) cases have been reported in most countries around the world, with the World Health Organization (WHO) has announcing COVID-19 as a pandemic on 11 March 2020.⁵ By 15 April 2020, more than 1,900,000 cases of COVID-19 had been reported all over the world.⁶

As healthcare workers, we are at the front line of the COVID-19 outbreak response and exposed to hazards at risk of infection. There are a lot of healthcare workers infected by COVID-19 all over the world. Several spine surgeons had been infected by COVID-19 after performing posterior lumbar interbody fusion for a patient during the incubation period of COVID-19 on 10 January 2020 in our hospital. During the pandemic of COVID-19, surgeries become restricted to urgent or emergency cases, such as trauma, infections, malignant tumors and so on. Some patients with COVID-19 may also need emergency

surgeries. As spine surgeons, it is our responsibility to ensure appropriate treatment to the patients with COVID-19 and spinal diseases.

Up to now, there has been little information about the operation protocol and the standard of personal protective equipment (PPE) for healthcare workers in the operating room when performing surgical procedures on patients with COVID-19. In the present manuscript, a protocol for spinal surgery and related management on patients with COVID-19 has been reviewed.

Pathogenic and epidemiologic characteristics of COVID-19. SARS-CoV-2 is the seventh coronavirus known to cause human disease, with a diameter varied from about 60 to 140 nm⁴. Among these viruses, three of them have been linked to fatal illness, including severe acute respiratory syndrome coronavirus (SARS-CoV), Middle East respiratory syndrome coronavirus (MERS-CoV) and SARS-CoV-2⁴. SARS-CoV-2 is sensitive to ultraviolet light and heat and can be inactivated at 56 °C for 30 minutes. Besides, ethyl ether, 75% ethanol, chlorine disinfectant, peracetic acid, and chloroform are effective in inactivating the virus.

Both patients confirmed with COVID-19 and asymptomatic carriers play role in the

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transmission of SARS-CoV-2.^{7,8} The routes of transmission of SARS-CoV-2 were thought to be similar with SARS-CoV, MERS-CoV, consisting of respiratory droplets and direct contact.⁸ Aerosol, blood, gastrointestinal tract, saliva, tears, and urine may also play role in the transmission of SARS-CoV-2.⁸⁻¹²

Clinical manifestations and preoperative examination. The common clinical features of patients with COVID-19 included fever, dry cough, dyspnea, myalgia, fatigue and so on.^{1-3,8} When a patient suspected or confirmed with COVID-19 and spinal disease presented to the fever clinic or department of emergency of our hospital, history inquiry, physical examination should be performed. Preoperative radiographs should include chest x-ray film, anteroposterior and lateral radiographs of the spinal lesions. A CT scan of chest and the spinal lesions should be performed.¹³ An MRI of the spinal lesions should also be performed as soon as possible. Electrocardiogram is necessary. Preoperative laboratory examination should include blood routine, blood biochemistry, coagulation function, C-reactive protein, erythrocyte sedimentation rate, muscle enzyme, troponin, procalcitonin, D-dimer, interleukin-6, rapid nucleic acid amplification test for influenza A and B, nasopharyngeal and oropharyngeal swabs test for SARS-CoV-2 and serum specific antibodies (IgM/IgG) of SARS-CoV-2.^{1,2,4,8,10} Blood gas analysis should be performed in necessary.

Based on the clinical presentations, imaging features and the laboratory examinations, the severity of illness in patients with COVID-19 can be categorized as mild, moderate, severe, and critical.

Patient preparation for emergency surgeries. Multi-speciality evaluation systems, including spine surgeons, anesthesiologists, critical care medicine physicians, respiratory physicians, infectious diseases physicians, officers in charge of infectious control, and nurses of the operating room, is necessary to evaluate the risk of the emergency surgeries and determine the surgical plans.¹⁴ Online or telephone consultation may also be helpful to reduce unnecessary meeting of the healthcare workers.

The American Society of Anesthesiologists (ASA) physical status classification should be determined by skilled anesthesiologists. All the patients with COVID-19 should be carefully evaluated before emergency surgeries because postoperative pneumonia may be aggravated.¹⁵

Indications and contraindications of emergency surgeries. Patients with COVID-19 and following spinal diseases should undergo emergency surgeries, including spinal fracture; spinal cord injury; spinal cord compression caused by intraspinal haematoma, intraspinal tumour or spinal infectious diseases; cauda equina syndrome; and other urgent illnesses.

Critically ill patients with COVID-19 may not able to endure the spinal surgeries, especially patients with multiple organs failure. Be cautious to perform surgeries

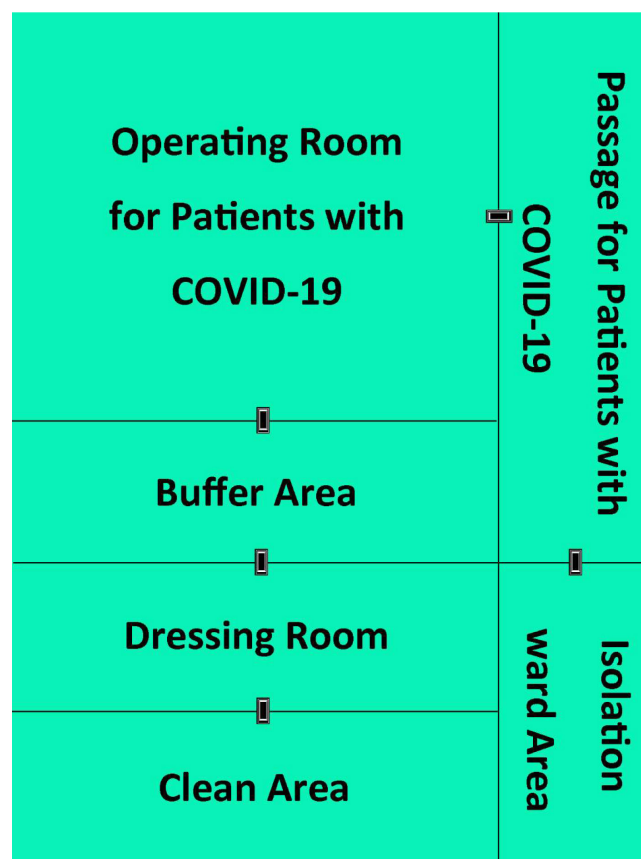


Fig. 1

Subregions of the dedicated operating room for patients with COVID-19.

for critically ill patients with COVID-19 because of the considerable mortality.^{16,17}

Operating room preparation. The dedicated operating rooms should be equipped with negative pressure system, and an appropriate level of negative pressure (-5 Pa) must be ensured to reduce the dissemination of COVID-19. Appropriate laminar flow and the functional high-efficiency filter of the operating rooms should be confirmed by the professional technical personnel. In some hospitals without negative pressure operating rooms, the positive pressure system and air conditioning of the dedicated operating rooms must be turned off. However, an operating room with good ventilation or high rate of air exchanges can also be used for patients with COVID-19 because more than 99% of the original viral load in the room will be cleared after five air exchanges.¹⁸ The dedicated operating rooms should be with appropriate subregions (surgery area, buffer area, dressing area and clean area) and two independent passages for healthcare workers and patients, respectively and labeled "COVID-19 surgery" (Figure 1). The operating table, instrument table, anesthesia machine, surgical microscope and C-arm fluoroscope should be prepared. Disposable surgical, anesthetic materials, and medications should also be prepared.

Table I. Personal protective equipment (PPE) for healthcare workers in the operating room.

Protection level	Personal protective equipment	Scope of application	Healthcare workers in the operating room
Level I	Disposable surgical cap; Disposable surgical mask; Work uniform/ Surgical undergarments; Disposable latex gloves; Disposable isolation clothing if necessary	Clean area; Ward area for patients without COVID-19; Operating room for patients without COVID-19	Healthcare workers in the clean area
Level II	Disposable surgical cap; Medical protective mask (N95 or FFP2 respirator) and disposable surgical mask; Surgical undergarments; Disposable medical protective uniform; Disposable isolation clothing; Disposable latex gloves; Goggles; Waterproof surgical shoe covers	Fever clinic; Non-respiratory specimen examination for patients with COVID-19; Imaging examination for patients with COVID-19; Isolation ward area (including isolated intensive care unit) for patients with COVID-19; Dedicated operating rooms for patients with COVID-19; Perform surgery for patients with COVID-19; Cleaning of surgical instruments used with patients with COVID-19	Surgeons; Scrub nurses; Circulating nurses; Radiology technicians; Other healthcare workers in the isolated area
Level III	Disposable surgical cap; Medical protective mask (N95 or FFP2 respirator) and disposable surgical mask; Surgical undergarments; Disposable medical protective uniform; Disposable isolation clothing; Disposable latex gloves; Goggles; Waterproof surgical shoe covers; Full-face respiratory protective devices or powered air-purifying respirator	Collect nasopharyngeal swab specimen for patients with COVID-19; Perform operations such as tracheal intubation or tracheotomy, during which, the patients with COVID-19 may spray or splash respiratory secretions or body fluids/blood	Anesthesiologists; Nasopharyngeal swab specimen nurses

**Fig. 2**

Personal protective equipment for a surgeon. (Provided by Dr. Y. G.).

Infection control precautions and personal protective equipment (PPE). Visitors or staff who have been exposed to COVID-19 should not be allowed to enter the operating room. All healthcare workers should receive system training on in-hospital infection control about COVID-19. Appropriate PPE is very important to prevent the infection of SARS-CoV-2 when diagnosing and treating patients with COVID-19 in fever clinic, isolation ward, intensive care unit (ICU) and the operating room. PPE for different healthcare workers in the dedicated operating room for patients of COVID-19 were listed in Table I.¹⁸ PPE

for a surgeon was presented in Figure 2. In some district with inadequate supply chains, appropriate PPE use is also important to avoid PPE overuse. Hand hygiene must be performed after contact with the patients with 2% to 3% hydrogen peroxide gel or solution, or by washing hands with soap and water.

Anesthesia management. An anesthesia machine is dedicated to a dedicated operating room. A breathing circuit filter must be installed between the proximal end of the endotracheal tube and the distal end of the circuit.¹⁴ The spinal surgeries should be performed under general anesthesia. After a complete satisfactory check of PPE for each healthcare worker in the operating rooms, a rapid sequence induction should be initiated.¹⁴ During preoxygenation, the patient's mouth and nose should be covered with two layers of wet gauze to block the secretions, then the anesthesia mask should be superimposed onto the wet gauze.¹⁴ Oral intubation with a video laryngoscope or bronchoscope is preferred.¹⁴ It is recommended to use a closed airway suction system to reduce the viral aerosol production.¹⁴ All the aerosol generating procedures should be undertaken in the negative pressure operating rooms with the doors shut.¹⁸

After surgeries, the mild or moderate patients should be extubated in the operating rooms, then transferred directly back to the isolation ward. While severe and critical ill patients should be sent to the isolated ICU for patients with COVID-19, then extubated in ICU.¹⁴ Two layers of wet gauze should also be used to cover the



Fig. 3

A group of surgeons were performing a posterior lumbar surgery on a patient with COVID-19. (Provided by Dr. Y. G).

patient's mouth and nose to block the secretions during extubation.¹⁴

Intraoperative procedures. The patients will be in the supine or prone position according to the surgeries to be performed. Posteroanterior and lateral fluoroscopy should be obtained by C-arm fluoroscopy to locate the surgical segments. Disposable surgical isolation clothing and sterile latex surgical gloves should be worn outside the PPE. A group of three or four spine surgeons is necessary to perform the surgeries (Figure 3). Then the spinal surgeries will be performed as usual.

Surgical smoke generated during the surgeries may be harmful to the surgeons, with the risk of transmission of infectious diseases, mutagenicity, and direct physical injury.¹⁹ Some viruses, such as human papillomavirus and HIV proviral DNA, can be detected in the surgical smoke.¹⁹ Disposable surgical masks and high-efficiency particulate air respirators, such as N95 or FFP2 respirators, were of filtration efficiency higher than 90% and 99%, respectively.¹⁹ However, submicrometer-size particles can be filtered by N95 or FFP2 respirators, while only 5 μm or larger particles can be filtered by the disposable surgical masks. As a result, PPE of protection level 2 may be safe for the surgeons to prevent the infection of COVID-19. Frequency and time of electrocoagulation should be lower to reduce the generating of surgical smoke. Ultrasonic osteotome, which can produce aerosol, should not be used for the patients with COVID-19. Blood, tissue fluid, cerebrospinal fluid, and irrigation fluid should be cleared in time by the negative pressure suction pipes to reduce liquid splashing. Intraoperative procedures should be gentle to reduce liquid splashing. Be careful to prevent needle stick or cutting injury. Before closure, wound negative pressure drainage devices should be used to reduce the contamination of drainage fluid after surgeries.

However, it may be uncomfortable and cumbersome to perform the surgeries with PPE for hours. Moreover, goggles with fog may prevent the surgeons from observing the surgical field, making the surgeries being more difficult, technically demanding, and at higher risk of complications.

Postoperative management and medical waste disposal. All the disposable materials and medications must be used for only one patient exclusively. All anesthesia and surgical equipments should be cleaned and disinfected promptly. The dedicated operating rooms for patients with COVID-19 should be fully disinfected with 2% to 3% hydrogen peroxide sprays, and then wiped with 2% to 3% hydrogen peroxide, 2 to 5 g/l chlorine disinfectant, or 75% alcohol. The transfer bed used for patients with COVID-19 should also be disinfected with 2 to 5 g/l chlorine disinfectant. Sufficient training on medical equipment cleaning and disinfection in the dedicated operating rooms for the cleaning personnel is essential. A checklist of the operating rooms should be kept by the infection control team in a timely manner.

All the medical waste should be double-bagged and labelled with "COVID-19", then sealed and sprayed with chlorinated disinfectant or covered with an additional bag. Standard handling of medical waste disposal should be known to prevent needle stick or cutting injury. Disposable surgical isolation clothing and sterile latex surgical gloves should be taken off in the operating rooms. All healthcare workers participating in the surgeries should remove their PPE and place the PPE in the designated medical waste bags in the buffer area. After showering in the dressing room area, healthcare workers can leave away.

Surveillance of healthcare workers after surgeries for patients with COVID-19. All front-line healthcare workers should be self-isolated at home or dedicated isolation medical observation area for 14 days. If any healthcare workers develop fever, cough or fatigue, they must inform the occupational health department of the hospital. Then a chest CT, nasopharyngeal and oropharyngeal swabs test for SARS-CoV-2 and serum specific antibodies of SARS-CoV-2 should be performed for them. The health status of healthcare workers with epidemiologic history, clinical manifestations of COVID-19 and positive results of above examinations should be monitored and recorded. A well-balanced diet should be provided for them to maintain good immunity. Healthcare workers confirmed with COVID-19 should be sent to the dedicated isolated wards for further treatment.

Discussion

Between 13 January and 28 March 2020, more than 50 surgeries have been performed on patients with COVID-19 in our hospital. However, none of the healthcare workers in the operating room were infected by COVID-19 until

now. During the pandemic, more emergency surgeries will be performed on patients with COVID-19; therefore, it may be of great importance to share our experience. All healthcare workers in the world should work together to fight against COVID-19.

In summary, we make some specific recommendations for the emergency surgeries performed on patients with COVID-19:

1. Multi-speciality evaluation system is necessary to evaluate the risk of the emergency surgeries and determine the surgical plans.
2. Operating rooms with negative pressure system or good ventilation should be used to reduce the dissemination of COVID-19.
3. The dedicated operating rooms should be with appropriate subregions and two independent passages for healthcare workers and patients, respectively.
4. All healthcare workers should receive system training on in-hospital infection control about COVID-19.
5. Appropriate PPE is very important for the healthcare workers to prevent the infection of COVID-19.
6. Appropriate anesthesia management should be performed to reduce the aerosol generating in the operating room.
7. Appropriate intraoperative procedures are necessary to reduce liquid splashing and contamination of drainage fluid.
8. Postoperative disinfection of the operating room and medical waste disposal are very important.
9. Surveillance of healthcare workers after surgeries is necessary to monitor the health status of them and reduce potential nosocomial spread of COVID-19.

Conclusion

It should be safe for surgeons with PPE of protection level 2 to perform spinal surgeries on patients with COVID-19. Standardized and careful surgical procedures should be necessary to reduce the exposure to COVID-19.

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- W. Hua: Wrote the paper.
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- X. Wu: Collected the data.
- Y. Gao: Performed spinal surgeries on patients with COVID-19.
- C. Yang: Collected the data, Wrote the paper.

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