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## Major Article

# Practice and exploration of infection prevention and control measures based on risk management of surgical patients during the epidemic of corona virus disease 2019 (COVID-19)



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## Key Words:

SARS-CoV-2  
Operation  
Risk assessment  
Personal protective equipment

**Background:** An outbreak of corona virus disease 2019 (COVID-19) in Wuhan, China has spread quickly across the world, the World Health Organization (WHO) has declared this a pandemic. COVID-19 can be transmitted from human to human and cause nosocomial infection that has brought great challenges to infection control in medical institutions. Due to the professional characteristics, the research hospital still received a large number of trauma emergency tasks during the outbreak. It is urgent to establish a graded prevention and control guidance of surgery.

**Methods:** Review the implementation of surgical grading control measures in this hospital during the epidemic of COVID-19.

**Results:** The surgical prevention measures based on patients with different risks included prescreening and preoperative risk assessment, preparation of operating room, medical staff protection and environmental disinfection measures, etc. From January 20 to March 5, 2020, a total of 4,720 operations had been performed in this hospital, of which 1,565 were emergency operations and 22 for medium-risk and high-risk patients who may have the 2019 severe acute respiratory syndrome coronavirus 2 infection. And there is no medical staff exposed during the implementation of protective measures.

**Conclusions:** Through the risk assessment of surgical patients and adopting surgical grading control measures, the risk of severe acute respiratory syndrome coronavirus 2 spread during the surgical process can be reduced greatly.

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In December 2019, an outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection that causes corona virus disease 2019 (COVID-19) occurred in Wuhan, Hubei Province, China. With the spread of the epidemic, cases have spread to other regions of China and abroad.<sup>1,2</sup> On January 20, 2020, National Health Commission of the People's Republic of China incorporated the COVID-19 into the category-B infectious diseases stipulated in the Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases and managed it according to Class A. On January 30, 2020, World Health Organization (WHO) has declared COVID-19 as the sixth public health emergency of

international concern, and on March 11, 2020, WHO has declared this a pandemic. The control situation is very grim. SARS-CoV-2 is thought to be transmitted through respiratory droplets and contact. There is a possibility of aerosol transmission when people exposed to high concentrations of aerosol for a long time in a relatively enclosed environment. The population is generally susceptible to the disease. COVID-19 patients are the main source of infection, and patients with mild or no symptoms can also transmit the virus to others.<sup>3,4</sup> A study suggested that there is a more efficient transmission of SARS-CoV-2 than SARS-CoV when symptoms are still minimal and restricted to the upper respiratory tract.<sup>5</sup> Zhang et al estimated R0 (R0 is used to estimating the transmissibility of virus) of SARS-CoV-2 was about 2.28 (2.06–2.52) at the early stage, which is similar to the R0 value estimated by WHO.<sup>6,7</sup> The future incidence rate and the possible outbreak scale depend largely on the change of R0. Unless strict infection management and control measures are taken, COVID-19 may cause a greater outbreak.<sup>7</sup> The hospital in

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the study is a tertiary medical center in Beijing, which specialized in orthopedics and burn. During the epidemic period, although the number of patients undergoing elective surgery was significantly reduced, the hospital still received a large number of emergent trauma patients in Beijing and surrounding provinces who need emergent surgical intervention. National Health Commission of the People's Republic of China and various professional committees related to surgery have issued guidelines and procedures, but there are no detailed guidelines for grading prevention and control management based on the risk assessment of surgical patients. This paper discusses the risk assessment and management of surgical patients during the epidemic period based on relevant national regulations, guidelines and literature, combined with the surgical prevention and control measures carried out by the hospital and the effects after implementation.

## ORGANIZATION AND MANAGEMENT

### *Emergency system of operation risk management*

The hospital set up a dedicated team for the prevention and control of COVID-19, and established an emergency system for surgical risk management based on risk management theory. The department of Hospital-Acquired Infection Control in the hospital is responsible for comprehensive process setting and technical guidance. The chief of the operating department and the head of the operating room are responsible for organizing the implementation of infection prevention and control in the operating room.

### *Training and assessment of all staff*

In accordance with the diagnosis and treatment specifications, prevention and control plans, disinfection and isolation measures, use of personal protective equipment (PPE), and the plan process of the hospital and section, various forms of training and assessment have been continuously carried out, and emergency drills have been carried out on a regular basis. The trained personnel involved surgeons, nurses, cleaners, etc., and each staff should master the technical points and details of their work.

### *Material reserves*

During the epidemic of the COVID-19, in addition to the protective equipment required for routine surgery, the operating room should be fully stocked with PPE emergency package based on the risk of suspected or confirmed COVID-19, including: medical protective masks, disposable caps, medical protective clothing, goggles or splash screens, disposable sterile surgical gowns, isolation gowns, sterile gloves, and boot covers. An instruction manual for PPE is placed in the emergency package. In addition, sufficient environmental disinfection supplies should be stocked.

## PRESCREENING TRIAGE AND PREOPERATIVE RISK ASSESSMENT

During the epidemic of COVID-19, all patients entering the hospital need to take a temperature test at the hospital entrance. Before the patient enters the outpatient department or the emergency department, the staff of the precheck triage department will conduct temperature test on the patient again, and ask about the patient's epidemiological history and respiratory symptoms in detail. Patients who are normal in the above items can see a doctor normally. All patients with  $T \geq 37.3^{\circ}\text{C}$ <sup>8,9</sup> or patients with both epidemiological history and respiratory symptoms should go to the fever clinic for further screening. In addition, there are a large number of patients with simple epidemiological history, respiratory symptoms, or

abnormalities in pulmonary imaging that require treatment, in view of these patients, the doctors should fully evaluate the necessity of emergency surgical treatment combined with patients' clinical condition. If the patient's condition allows the operation to be delayed, the patient should be isolated until COVID-19-related factors disappear or the patient recovers from COVID-19 as far as possible. If the patient must receive emergency surgical treatment, a series of protective measures should be taken according to the risk assessment. At present, since the diagnosis of COVID-19 requires the detection of nucleic acids or serum antibodies, the collection, transportation, and testing of these specimens take a long time, ranging from 4 to 5 hours to 2 to 3 days, and there is a percentage of false-negative rate in these tests.<sup>10</sup> Therefore, in order to reduce the risk of nosocomial transmission of COVID-19 due to surgical operation, a risk assessment mechanism for surgical patients should be established. According to the patient's epidemiological history, clinical manifestations, bilateral spiral CT examination, and surgical anesthesia, the risk levels of surgical patients should be scientifically classified.<sup>3,11</sup> It is mainly divided into low risk, medium risk, and high risk. The risk assessment should focus on 2 opportunities, one is the preoperative evaluation of the doctor in charge and the other is the assessment of the anesthesiologist and the operating nurse. According to the results of the evaluation, different levels of prevention and control measures should be implemented accurately during the operation. [Table 1](#) shows the risk assessment and classification of surgical patients.

## GRADED PREVENTION AND CONTROL MANAGEMENT OF SURGERY

### *Basic requirements*

According to the risk classification of surgical patients, the prevention and control measures of basic-level, enhanced-level, and strict-level are implemented ([Table 1](#)). For patients with low risk, the basic-level prevention and control measures (Level-I) can be taken for the operation, and the operation can be carried out according to the routine procedure. For patients with medium risk, enhanced-level prevention and control measures (Level-II) should be implemented. The doctor in charge shall report to the department director before the operation and inform the medical staff in the operating room to improve the protection level, and the rest work should be carried out according to the routine procedure. For patients at high risk, strict-level prevention and control measures (Level-III) should be implemented. The department director shall organize the department to discuss the necessity and urgency of emergency surgery for cases. If surgery is needed, a series of prevention and control measures shall be strictly implemented to ensure the safety of patients and medical staff.

### *Preoperative preparation*

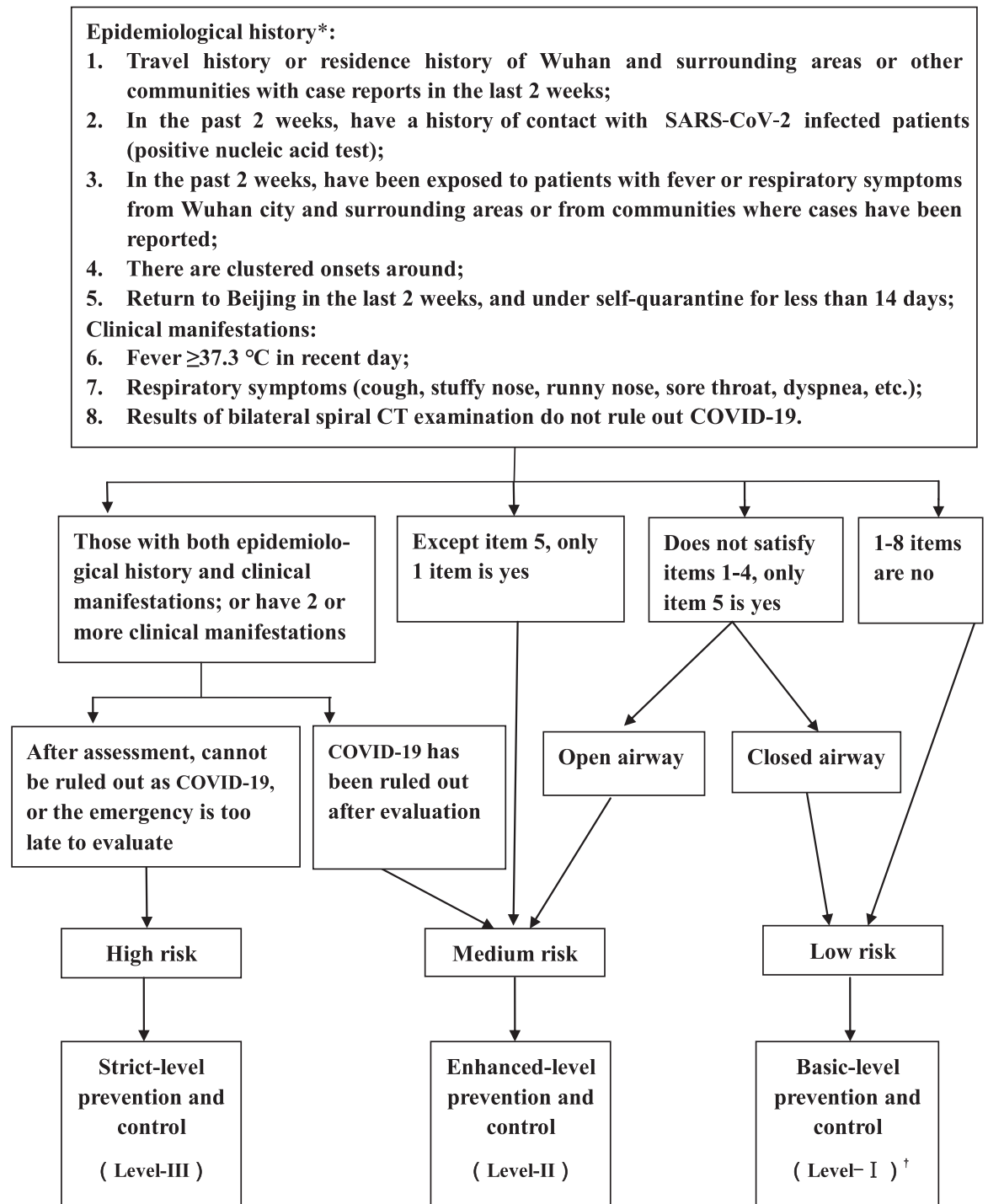
#### *Division of labor and preparation of items*

The operating room staff is prepared according to the division of labor requirements, including telephone notification to the auxiliary departments, adjusting the functions of the operating room, preparing PPE and disinfection supplies, preparation for receiving patients, contact person and scheme for emergency handling of accidents during operation, etc.

#### *Operating room selection*

Surgery of Level-I is performed in the conventional positive pressure operation room. Surgery of Level-II and Level-III are preferably performed in a negative pressure operating room, or general operating room which is conducive to isolation and partition, and has no laminar flow technology,<sup>12,13</sup> and those in other countries should

**Table 1**  
Risk assessment and classification of surgical patients



\* According to the development of the epidemic situation, the risk areas involved in the epidemiological history in Table 1 should be adjusted in time according to the risk areas publicly disclosed by government departments or WHO.

† Level-I, basic-level prevention and control measures; Level-II, enhanced-level prevention and control measures; Level-III, strict-level prevention and control measures.

follow existing national guidelines for surgical care of patients with active TB or COVID-19.

*Patient transport*

Surgery is performed for patients with medium and high risk, and then the patient transfer process may cause the transmission of

SARS-CoV-2. Staff should choose a route with low traffic flow, short time and close distance, and should inform the designated elevator in advance to make preparations to minimize the stay. The security personnel should direct the way to ensure that no other personnel are close within 1 m around the patient. For the surgery of Level-II, patients and transport personnel should wear medical surgical

masks. Surgery of Level-III, patients wear medical surgical masks, it is recommended to wear medical protective masks if the patient is able to tolerate it. Transport personnel should wear isolation gowns, medical surgical masks or medical protective masks, caps, gloves, goggles/splash screens, carry an alcohol-based hand rub, and timely do hand hygiene for preventing contamination of the environment along the way. The elevator should be suspended after use for thorough disinfection. The keys and surfaces should be wiped with 1,000 (ppm) chlorine-containing disinfectant. The elevator can be used after 30 minutes of door opening and ventilation. Establish emergency response team and directory for patient transport, including operating room, elevator operation, security department, medical department, and department of infection control, hospital general duty department, to jointly ensure the smooth and safe transport of patients.

**Personnel protection**

All surgical personnel involved should select appropriate protective equipment according to the level of exposure. The basic-level protection, that is, the medical staff in the basis of standard prevention, in accordance with the daily operation requirements to wear protective equipment; the enhanced- and strict-level protection improve the standard of protection according to the increase of exposure risk of personnel. Table 2 shows the classification of surgical protection for medical staff.

**Intraoperative prevention and control**

For surgery with Level-III, the disposable instruments, appliances, and articles should be selected as much as possible. Before the operation, articles unrelated should be removed from the operating room, and "Isolation" warning signs should be hung outside the door, operators should be simplified, and people flow and logistics should be strictly controlled. The doors of the operating room and buffer room should be closed in time. We chose to adjust the pressure in the operating room to be negative at -5 Pa; however, those in other countries should follow existing national guidelines for surgical care of patients with active TB or COVID-19.<sup>12,13</sup> The way of not opening the airway is preferred in anesthesia. When the airway must be opened due to the disease, the contamination of droplets produced by choking cough should be careful. The use of aerosol protection devices can reduce the risk of splashing operations.<sup>14</sup> After entering the operating room, the patient can use a nasal catheter to inhale oxygen while wearing a surgical mask. If it is necessary to use electric knife, ultrasonic knife, irrigation gun during the operation, aerosol may be generated. The

lowest effective power should be selected as much as possible, and a smoking device should be used.<sup>15,16</sup> During the operation, the irrigating fluid and drainage fluid should be minimized to avoid spillage of blood and body fluids. The noncontact transfer method is adopted to transfer surgical instruments. It is suggested to use stab proofneedles to reduce the risk of occupational exposure.

PPE will affect the accuracy of anesthesia and surgery. While avoiding occupational exposure, medical personnel should avoid the negative impact of the use of protective equipment in the implementation of diagnosis and treatment, and pay attention to aseptic operation to prevent patients from surgical site infection.

**Postoperative management**

**Personnel management**

The anesthesia recovery room is usually a positive pressure clean room. In order to reduce the environmental contamination of the operating room, for patients who may have COVID-19 at medium or high risk, it is not recommended to resuscitate in the anesthesia recovery room after general anesthesia. Patients can be placed in the previous surgery room or intensive care unit negative pressure isolation room. In order to reduce coughing, patients should be extubated under good analgesic conditions.<sup>11</sup> After the operation, the participants should remove the protective equipment in the right area according to the requirements of the clean and soiled area of the operating room, avoid contaminating the skin and the innermost clothes, and leave the operating room after bathing and changing clothes. All personnel involved in the surgery need to receive exposure risk assessment after surgery. If the participants involved in accidental exposure during the operation of COVID-19 patients or during the removal of protective equipment, they should be medically observed for 14 days. During the observation, their body temperature, clinical symptoms, and signs should be monitored daily, and if there is any abnormality, they should be treated in time. If there is no accidental exposure in the whole process, they can apply for exemption from isolation.<sup>11,15</sup>

**Environmental disinfection**

These disinfection measures mainly follow existing national guidelines and the guidance about environmental disinfection from WHO.<sup>17-21</sup> For surgeries of level-I and level-II, routine mode of disinfection measures can be adopted. As for the surgeries of Level-III, the contaminated environment and articles should be strictly disinfected at the end of the operation, only after that can routine

**Table 2**  
Classification of surgical protection for medical staff

| SARS-CoV-2 infection risk rating for surgical patients | Protection level |   | Personal protective equipment  |
|--|------------------|---|--|
| Low risk   | Basic level      |   | Medical surgical mask, disposable cap, sterile surgical gown, disposable sterile gloves  |
| Medium risk  | Enhanced level   | Surgeon and instrument nurse                        | Medical protective mask, disposable cap, goggles or splash screen, disposable sterile surgical gown, double-layer sterile gloves and boot covers   |
|  |                  | Anesthesiologists and circulating nurse             | Medical protective mask, disposable cap, goggles or splash screen, disposable impermeable isolation gown and boot covers   |
| High risk  | Strict level     | Surgeon and instrument nurse*                       | Medical protective mask, disposable cap, goggles (splash screen if necessary), disposable protective clothing, disposable sterile surgical gown, double-layer sterile gloves and boot covers |
|  |                  | Anesthesiologist and circulating nurse <sup>†</sup> | Medical protective mask, disposable cap, goggles or splash screen, disposable protective clothing, disposable impermeable isolation gown, double latex gloves and boot covers                |

\*The order of wearing is to wash hands, wear disposable cap, medical protective mask and goggles, wash hands and do surgical hand disinfection, wear protective clothing, put on splash screen(if necessary), wear boot covers, disinfect hands, wear the first layer of sterile gloves, wear sterile operating gown and the second layer of sterile gloves.

<sup>†</sup>The wearing sequence is to wash hands, wear disposable cap, wear medical protective mask and goggles, wear protective clothing and boot covers, disinfect hands, wear the first layer of latex gloves, wear disposable impermeable isolation gown, and wear the second layer of gloves.

**Table 3**  
The terminal disinfection measures for Level-III surgery

|                                 | Disinfection items   | Disinfection method 1   | Disinfection method 2  |
|---------------------------------|--|---|--|
| Air*                            | General operating room   | Using the atomization way disinfection with hydrogen peroxide (3%), room closed >1 hour   | Ultraviolet radiation disinfection >1 hour   |
|                                 | Negative pressure operating room   | Before disinfection, shut off the laminar flow and air supply system, use the atomization way disinfection with hydrogen peroxide (3%), room closed >1 hour, after that, laminar flow and air supply system continue to run a self-purification cycle.  | —  |
| Surface of object               | Instrument table, equipment, operation table and filter screen of return airport, etc. | Surface that can be disinfected with chlorine disinfectants <sup>†</sup> : spray or wipe with chlorine-containing disinfectant (1,000 ppm) >30 minutes, and then wipe with clean water. For the surface with blood, body fluid and other pollutants of the patient, should be carefully removed with an absorbent material with chlorine-containing disinfectant (5,000 ppm), and then to be disinfected routinely. | Surface that cannot be disinfected with chlorine disinfectants: wipe with 75% alcohol for disinfection |
|                                 | Ground   | Use chlorine-containing disinfectant (1,000ppm) to spray and disinfect once from the outside to the inside, and disinfect a passage. After indoor disinfection, spray again from the inside to the outside, disinfection effect for more than 30 minutes. <sup>22</sup>   | —  |
|                                 | Wall   | Chlorine-containing disinfectant (1,000 ppm) is sprayed for disinfection. (If the wall is visibly soiled with blood/body fluids)  | —  |
| Anesthesia machine <sup>‡</sup> |  | The professional engineer disassembles the breathing circuit in the anesthesia machine and sends it to the disinfection supply center for sterilization.  | Disinfect with compound alcohol anesthesia circuit disinfectant <sup>23,24</sup>                       |
| Transport bed                   |  | After being disinfected by hydrogen peroxide (3%) spray in the operating room, chlorine-containing disinfectant (1,000 ppm) was used to wipe and disinfect.   | —  |

\*The disinfectant is atomized into tiny particles under 20 microns, uniformly sprayed in the air so as to make full contact with the microbial particles and kill the microorganisms. Before disinfection, protective sleeve should be used to protect the precision instrument from corrosion. These measures of air disinfection are formulated in accordance with domestic guidelines, and whole room disinfection with vaporized disinfectants is not necessary according to WHO guidance, so those in other countries should follow existing national guidelines or the guidance from WHO.<sup>18–21</sup>

<sup>†</sup>It is suggested that after the terminal disinfection in the operating room, the professional engineer dismantle the anesthesia machine, and then disinfect the local environmental surface after the dismantling.

<sup>‡</sup>In addition to chlorine-containing disinfectant, hydrogen peroxide, and alcohol, there are other disinfectants that have been proven to be effective against SARS-CoV-2.<sup>20,25,26</sup>

surgery be performed. Table 3 shows the terminal disinfection measures for Level-III surgery.

#### Changing the high efficiency particulate air filter

After the operation of suspected or confirmed patients of COVID-19, the laminar flow engineer should evaluate that if the high efficiency particulate air filters need to be replaced. If necessary, the engineer should wait for the completion of the terminal disinfection before entering, and should wear disposable isolation clothing, medical protective masks and goggles (or splash screen). When the replacement is completed, the local environmental surfaces need to be disinfected again.

#### Processing of reusable surgical instruments

All reusable surgical instruments should undergo standard transport, cleaning, and sterilization procedures. The routine processing of surgical instruments is effective and safe.<sup>27</sup> Medical masks, eye protection, gloves, and gowns should be worn by personnel responsible for cleaning these instruments prior to sterilization.

In some countries, the processing procedures of reusable surgical instruments for suspected or confirmed patients with COVID-19 follow the principles of disinfection first, then standard transport, cleaning, and sterilization.<sup>28</sup> These are safety protection measures formulated in combination with the current situation of the country, and that in other countries should be implemented follow WHO and existing national guidelines.

#### Health care waste treatment

All health care waste produced during surgeries of Level-I, Level-II, and Level-III are considered to be infectious (infectious, sharps, and pathological waste) and should be collected safely in clearly marked lined containers and sharp safe boxes. All those who handle health care waste should wear appropriate PPE (boots, long-sleeved gown, heavy-duty gloves, mask, and goggles or a face shield) and perform hand hygiene after removing it.<sup>29</sup>

#### THE OPERATION OF THE HOSPITAL DURING THE COVID-19 EPIDEMIC PREVENTION AND CONTROL

On January 20, 2020, the first confirmed case of COVID-19 was reported in Beijing. As of March 5, 2020, a total of 418 confirmed cases were reported. During this period, a total of 4,270 operations were performed in the hospital, of which 2,705 were elective surgeries and 1,565 were emergency surgeries, with a different degree of decline compared with the same period last year, as shown in Table 4. There were 4,248 surgical cases of Level-I, 21 surgical cases of Level-II, and 1 case of Level-III. No accidental exposure of medical staff was found in the postoperative evaluation, as shown in Table 5.

#### DISCUSSION

During the prevention and control of the COVID-19 epidemic, the hospital evaluated its high-risk areas and the main links of nosocomial infection management in advance, and formulated relevant plans and procedures according to different stages of the epidemic development.

**Table 4**

Comparison of the number of surgical cases in 2019 and 2020 from January 20 to March 5

| Surgical category | Number of cases in 2019 | Number of cases in 2020 | Reduced number of cases | Reduction rate (%) |
|-------------------|-------------------------|-------------------------|-------------------------|--------------------|
| Selective surgery | 7,000                   | 2,705                   | 4,295                   | 61.4               |
| Emergency surgery | 2,174                   | 1,565                   | 610                     | 28.1               |
| Total             | 9,174                   | 4,270                   | 4,905                   | 53.5               |

In the early stage of the COVID-19 epidemic, it coincided with the Chinese Spring Festival holiday. At the same time, the city of Wuhan and surrounding areas began to take strict control measures to restrict the flow of people. The number of inpatients and surgical patients in general hospitals decreased significantly, but the number of outpatients and emergency respiratory infectious patients was large. At this stage, the hospital focused on the infection prevention and control management of outpatients and emergency departments.

As the Spring Festival holiday is coming to an end, the COVID-19 epidemic situation has gradually developed to reach the peak period. With the return of large-scale personnel to work, the hospital has ushered in the peak of daily medical consultations. At this time, the situation of epidemic prevention and control was more severe. The hospital timely assessed risks, shifted the focus of prevention and control work, and formulated a series of preplanned procedures and work plans. On the basis of ensuring strict control of outpatient and emergency department, the hospital further strengthen the management of infection control for hospitalized and surgical patients.

In order to rationally guide patients and prevent the spread of the epidemic, the hospital has adopted control measures to reasonably control the number of operations and arrange the operation time according to the surgical indications, that is, to ensure that emergency operations are carried out in a timely manner, and non-emergency operations are postponed. From the statistics of the operation volume during the outbreak of the hospital, it can be seen that elective surgery has decreased by 61.4% compared with the same period of last year, indicating that the control measures are very effective. However, it can be seen from the indicator that the emergency surgery only decreased by 28.1%. As the Beijing Burn and Trauma Rescue Center, the hospital still undertook a large number of trauma emergency tasks during the epidemic.

Therefore, the development of effective surgical prevention and control measures and standardized work procedures are necessary measures to ensure the health and safety of patients and medical staff.<sup>30</sup> Based on the prominent risks faced by emergency surgery, the hospital has also developed a series of preventive and control measures for emergency surgery. These measures include: 1) For the patients who need to be hospitalized after the emergency department, adjust the layout and function of the ward, divided into isolation ward and general ward; 2) Apply the management of enhanced recovery after surgery clinical path to the emergency surgery patients flexibly, accelerate the patient's recovery and reduce the length of hospitalization; 3) Established emergency plan for failure to complete CT screening when pregnant women need urgent cesarean section, etc.

**Table 5**

The number of surgical cases and the exposure of medical staff in each level of surgical prevention and control from January 20 to March 5, 2020

| Level of surgical prevention and control | Number of surgical cases | Number of medical staff exposed (postoperative evaluation) |
|--|--------------------------|--|
| Level-I                                  | 4,248                    | 0  |
| Level-II                                 | 21                       | 0  |
| Level-III                                | 1                        | 0  |
| Total                                    | 4,270                    | 0  |

During the peak period of the COVID-19 epidemic, we screened out some patients with one or several high-risk factors of COVID-19 through the surgical risk assessment system, the hospital performed 4,270 surgeries for low-risk, medium-risk, and high-risk patients, and there is no medical staff exposed (the outcome of our assessment was whether the medical staff were exposed during the implementation of protective measures, rather than whether there was COVID-19 infection). So as long as appropriate protective measures were implemented and all were aware of this risk it would lessen any chance of occupational exposure.

Because there are only 22 cases with medium and high risk, and the COVID-19 confirmed by laboratory are insufficient, we will continue to accumulate surgical cases and practical experience in the follow-up study, and constantly improve the surgical risk assessment system, so as to make the research more in depth.

Most of the control measures in this study are consistent with WHO guidelines, and a few measures are based on domestic guidelines on the basis of practical feasibility, such as reprocessing of surgical instruments, selection of air disinfection and so on. Other countries are advised to refer to the WHO and existing national guidelines for comprehensive reference.

## CONCLUSIONS

During the COVID-19 epidemic, the hospital established a surgical risk assessment mechanism in accordance with existing national guidelines and the guidance from WHO, and adopted a series of surgical grading control measures, the risk of SARS-CoV-2 spread during the surgical process can be reduced. It is hoped that the experiences of COVID-19 prevention and control mentioned in this study can provide useful reference for colleagues around the world.

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