Recommendations of protective measures for orthopedic surgeons during COVID-19 pandemic

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Abstract

Purpose: It was the primary purpose of the present systematic review to identify the optimal protection measures and orthopedic treatment during COVID-19 pandemic and provide guidance for orthopaedic surgeons. The secondary purpose was to report the experience of an orthopaedic trauma center in Wuhan, China during the pandemic.

Methods: A systematic search of the PubMed, Cochrane, Web of Science, Google Scholar was performed for studies about COVID-19, fracture, trauma, orthopedic, healthcare workers, protection, telemedicine. The appropriate protective measures for orthopaedic surgeons and patients were reviewed (on-site first aid, emergency room, operating room, isolation wards, general ward, etc.) during the entire diagnosis and treatment process of traumatic patients.

Results: Eighteen studies were included, and most studies (13/18) emphasized that orthopedic surgeons should pay attention to prevent cross-infection. Only four studies have reported in detail how orthopedic surgeons should be protected during surgery in the operating room. No detailed studies on multidisciplinary cooperation, strict protection, protection training, indications of emergency surgery, first aid on-site and protection in orthopedic wards were found.

Conclusion: Strict protection at every step in the patient pathway is important to reduce the risk of cross-infection. Lessons learnt from our experience will help others to manage orthopaedic patients with COVID-19, to reduce the risk of cross-infection between patients and to protect healthcare workers during work.

Keywords: 2019 novel coronavirus; Novel coronavirus disease; 2019-nCoV; COVID-19; Fracture; Treatment and diagnosis; Cross-infection; Protection; Orthopaedic surgery; Traumatology.

Level of Evidence: Review, level IV

Introduction

In December 2019, the Coronavirus Disease 2019 (COVID-19) caused by coronavirus (2019-nCoV) was found in Wuhan (Hubei, China) [1] and then became a worldwide pandemic on 11th March 2020. Compared with severe acute respiratory syndrome (SARS) coronavirus, COVID-19 has a lower mortality, but it is more infectious and pathogenic [2-5]. According to statistics from Johns Hopkins University [6], a total of 3257520 cases of COVID-19 have been confirmed globally until 11am on 1 May, 2020. Due to the high infectivity of 2019-nCoV, the source of infection can be COVID-19 patients and asymptomatic infected people. The main routes of transmission of 2019-nCoV are respiratory droplets, close contact and aerosol transmission [2-5, 7-10]. Furthermore, COVID-19 has a latent period of 1-14 days, up to 24 days [10]. Therefore, in the process of patient treatment and diagnosis, there is a high risk of cross-infection to healthcare workers [12].

The pandemic of COVID-19 has brought great challenges at every step in the patient pathway, from pre-hospital, emergency diagnosis and treatment, emergency surgery, anesthesia, and perioperative management. In every step of treatment, the strategies for the treatment of trauma patients should be formulated and protective measures should be taken. What PPE should be worn, and what preventive steps should be undertaken by healthcare workers in different areas of the patient pathway? To date, there is only little guidance provided by WHO and evidence based literature about protective measures or guidelines addressing the entire treatment process of orthopedic trauma patients.

Hence, it is the primary purpose of the present systematic review to identify the optimal protection measures and orthopedic treatment during COVID-19 pandemic and provide

guidance for orthopaedic surgeons. The secondary purpose was to report the experience of an orthopaedic trauma center in Wuhan, China. As of March 26, 2020, a total of 23187 cases with COVID-19 including rescuing 1134 cases of acute and critical illness and more than 400 patients with ventilators have been treated in our institution (Hubei, China) located in the center of the epidemic, meanwhile, more than 300 cases with COVID-19 have underwent a various operation. The Orthopedic Department has handled more than 260 emergency cases. At our center guidance was developed in a learning by doing and consensus process [5, 7-11, 13, 24-26, 30]. Here it is described what was done and how it was implemented.

Materials and methods

A systematic review of the available literature was performed for articles published up to April 27, 2020 using the keyword terms “COVID-19”, “fracture”, “trauma”, “orthopedic”, “surgeon”, “healthcare workers”, “protection”, “telemedicine” in several combinations. The following databases were assessed: PubMed, Cochrane, Web of Science, Google Scholar, and all the publications were searched. The search was limited to English studies only. Studies in other languages were not included in this review.

Study selection

All peer-reviewed articles were considered. Randomized controlled trials (RCTs), prospective trials and retrospective studies as well as reviews and case reports were included in this systematic review. Two authors independently screened the titles and abstracts of all the

articles were identified. If the abstract and the full-text was unavailable, the paper was excluded. In the event of disagreement, a consensus was reached by discussion, if needed with the intervention of the senior author.

This systematic review was conducted in accordance with the established guidelines from Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA). However, due to the heterogeneity of available data it was decided to present the review in a narrative manner.

Data extraction

One author extracted data from all the selected original articles, which was repeated by two other authors. If there was no agreement between the three, the senior author was consulted. Where required, the corresponding authors were contacted for additional information. This review focused on protective measures in the entire diagnosis and treatment process.

Results

The initial literature search found 176 articles. After removing 23 duplicates, 153 studies were screened. Of the 153 studies, 126 were excluded after screening of the title and abstract. Additional 9 studies were excluded after full-text review. Thus, 18 articles were finally eligible for data extraction. Agreement between the reviewers on study selection was substantial at the title review stage (k = 0.705; 95% CI 0.563–0.828), almost perfect at the abstract review stage (k = 0.871, 95% CI 0.475–0.999), and perfect at the full-text review

stage (k = 1.0). Based on the analysis of levels of evidence, one study was classified as level III, fourteen studies were classified as level IV and the remaining three studies were classified as level V. Due to study design heterogeneity it was not possible to pool results across studies and perform a meta-analysis.

One case series study of the characteristics and early prognosis of COVID-19 infection in patients with fractures found that the mean age of 10 fracture patients (8 women and 2 men) with COVID-19 was 68.4±17.5 years old (range, 34 to 87). Eight (80％) with complications such as hypertension, diabetes, brain injury, etc., needed multi-disciplinary cooperation and comprehensive treatment, however, 4 (40％) patients eventually died [14]. One study from Italy advised to strengthen multidisciplinary teamwork (MDT) [15]. But there is no study that specifically reported which specialties needed to participate in the MDT and how to divide the work load. Many studies [16-20, 22] reported that using video or teleconference for morning rounds, electronic consultations, videoconferencing, digital outpatient and other telemedicine methods to provide medical guidance and follow-up instruction for patients can reduce unnecessary contact, limiting the spread of the virus and save protective materials.

One survey comprised 47 hand surgeons working in 34 countries [21], and found that the majority wore varying personal protective equipment (PPE) in the OR and outpatient clinics. Only 59.6% (28/47) of surgeons used body temperature monitoring by a thermal scanner or equivalent to screen COVID-19 patients. The medical treatment protocols without a consensus varied in terms of visitors, health professionals in the operating theatres, patient waiting areas, wards and emergency rooms [21]. One international survey of COVID-19 and

spinal cord injury (SCI)and disease found 5.8% of participants had screened their outpatients with SCI for COVID-19 and only 4.4% reported having a patient with SCI with the virus [22]. The other finding of this survey is that 53.3% of participants worked at an inpatient facility reported that only individuals with symptoms were screened [22]. Another survey of COVID-19 disease among orthopaedic surgeons from 8 hospitals in Wuhan found a total of 26 surgeons were diagnosed with COVID-19 [12], and the incidence varied from 1.5% to 20.7%. Training on prevention measures was found to have a protective effect (odds ratio [OR], 0.12). Wearing of respirator masks was also found to be protective (OR, 0.15). Not wearing an N95 respirator was a risk factor for infection with COVID-19 (OR, 5.20 [95% confidence interval (CI), 1.09 to 25.00]) as well as severe fatigue due to work overload (OR, 4 [95% CI, 1 to 16]) [12].

Delaying and cancelling elective surgery, and the clear-cut definition of emergency surgery are still under debate [14, 16, 18-21, 23-26, 29]. By delaying elective surgery, the risk of nosocomial infection of patients undergoing elective surgery can be reduced, and medical resources can be saved to deal with COVID-19 [24-28]. Emergency surgery in the context of the current crisis can be defined as urgent pathologies that could result in long-term disability and/or chronic pain if surgery is postponed [25]. The Ohio Hospital Association suggested that criteria for emergency surgery is “threat to the patient’s life if surgery or procedure is not performed, threat of permanent dysfunction of an extremity or organ system, risk of metastasis or progression of staging, risk of rapidly worsening to severe symptoms (time sensitivity)” [26, 28]. Trauma related fractures are the most common cause of

emergency surgery. The WHO and evidence-based literature have not given any detailed recommendations for emergency orthopedic treatment during COVID-19 pandemic.

There was no study concerning the management of an outpatient clinic and surgical activities and the challenges in handling with a high-volume practice during epidemic. Only one article offered important points and strategies to provide the highest level of safety to healthcare workers during the start-up phase. [29]

Most studies (13/18) emphasized that orthopedic surgeons should pay attention to personal protection when facing the COVID-19 pandemic to prevent cross infection [12, 15, 16, 18-21, 23-25, 28-30]. Four studies have reported in more detail on personal protection [19, 23, 28, 30]. Dedicated paths to quickly transfer urgent patients with suspected or confirmed COVID-19 to the designated operating room need to be established, and appropriate PPE in operating room established to reduce the occupational risk in treatment [19, 28]. Rodrigues-Pinto et al. shared their experience in operating room organisation: dividing the designated operating room into five zones (Entry dressing room; Anteroom, where the disinfection and surgical dressing take place; Operating room; Exit room and Exit dressing room) and performing different sterile procedures in different zones to reduce the risk of cross-infection [28]. Hirschmann et al. reviewed the current evidence and recommendations for PPE for orthopaedic and trauma surgeons [30]. The evidence found suggested that orthopaedic and trauma surgery using power tools, pulsatile lavage and electrocautery might lead to surgical aerosol generation and all body fluids contain a varying amount of virus particles. Strict protective measures should be taken during surgery.

The most commonly suspected areas of exposure during the entire diagnosis and treatment process were general wards (79.2%) followed by public places at the hospital (20.8%), operating rooms (12.5%), the intensive care unit (4.2%), and the outpatient clinic (4.2%) [12]. However, there are no studies about which level of protection for orthopedic surgeon should be recommended from on-site emergency to patient discharge. Only Hirschmann et al. [30] gave an evidence-based recommendation which PPE should be used to avoid occupational transmission of COVID-19 during surgery. Guidance at our center was developed in a learning by doing and consensus process. [5, 7-11, 13, 24-26] In summary, appropriate protective measures of orthopaedic surgeons during pandemic should be taken in different sites during the entire diagnosis and treatment process of traumatic patients (Table 1, Table 2).

Discussion

Establishment of a multidisciplinary team (MDT) for trauma and infection

When orthopedic trauma is caused by high-energy injury [33, 44], there may also be craniocerebral, thoracic and abdominal trauma [14, 31, 32], which is life-threatening and is usually managed by a multidisciplinary team (MDT), the so-called trauma team. In a COVID-19 environment this should also include the infection department. In COVID-19 designated hospitals it might be a combined trauma and infection MDT. The core members should consist of senior physicians and infectious disease prevention specialists who have received professional training in advanced trauma life support. The team needs to diagnose

and treat patients with trauma suspected or confirmed of COVID-19, and provide adequate guidance for strengthening pre-hospital and intra-hospital prevention and control of cross-infection according to the relevant documents and guidelines [5, 7-10, 24-26, 44].

On-site first aid

In principle, all patients with fractures which occurred in pandemic areas should be treated as suspected COVID-19 cases [2, 44]. The ambulance requires sufficient protective equipment and rescue equipment [9]. All medical personnel should be familiar with the symptoms of COVID-19 and should have received professional training in level-three personal protective equipment (PPE) [5, 8, 12, 14, 15, 23, 28, 30] (Table.1). In addition, all should be well educated in wearing and taking off a disposable hat, disposable protective clothing, long shoe cover, N95/FFP2 mask, goggles, double-layer gloves and protective face screen. PPE is important to minimise the chance of contact with body fluids of the wounded. Before arriving at the scene, all the healthcare workers and drivers involved in the pre-hospital emergency should take level-two PPE. For patients with contact with COVID-19 patients or exhibiting the symptoms of fever and/or respiratory symptoms, the pre-hospital emergency healthcare workers and drivers in the non-pandemic area should take level-two PPE in advance.

Transportation of the trauma patient to hospital

In principle, all the injured patients should be transported to the nearest hospital with proper isolation facilities, adequate levels of PPE and the ability to diagnose and treat COVID-19

patients. The ambulance is exposed to high concentration of aerosol for a long time in a relatively closed environment, and must be cleaned and disinfected thoroughly [2，3, 5, 7-10]. Negative pressure ambulances are preferred. Ambulance drivers need at least level-two PPE. Only patients with excluded infection of COVID-19 can be sent to the general emergency department, the rest should be sent to the COVID-19-designated hospital for treatment.

Protection of healthcare workers in the emergency room (ER)

All staff who receive patients with suspected or confirmed COVID-19 need at least level-two PPE in the emergency room (ER) [5, 8, 19, 23, 28] (Table 1). If the patient is unconscious, or his/her family members cannot describe the epidemiological history, the suspected cases shall be treated as COVID-19. During pandemic, all patients should be treated as suspected cases of COVID-19 (Table 2). Adequate PPE and disinfection of medical equipment is paramount [7-10].

Diagnosis of COVID-19

If possible, the hospital personnel should take sputum, nasopharynx swab or blood samples, using real-time fluorescent RT-PCR to rapidly detect viral nucleic acid or gene sequencing to make the final diagnosis. According to the guidelines [7] the MD team should make a suspected or confirmed diagnosis of COVID-19. If the patients who are sent to the emergency room are preliminarily assessed as suspected COVID-19, they might be transferred immediately to complete a chest CT scan [5, 7, 29]. All patients admitted should be screened

for 2019-nCoV (Table 3) [5, 20, 22, 29], and COVID-19 needs to be differentiated from traumatic wet lung.

Indications for emergency surgery

After the patient has arrived at the hospital, the pre-alerted infection-trauma MDT starts with their standard operating procedures such as checking vital signs, oxygen saturation, and treating life-threatening hemorrhage and combined injuries. If necessary, immediate emergency surgery should be performed. The main indications for emergency surgery are: trauma seriously endangering life or limb, such as fracture with hemorrhagic shock, suspected large blood vessel injuries and fracture with important organ injuries; Gustilo II-III open fractures, closed fracture with compartment syndrome, fracture with severe infection; unstable spine fracture with spinal cord injury (AIS grade C or below), or progressive aggravation of neurological dysfunction [18, 24-28, 34].

Patients with mild to moderate COVID-19 are treated as above, whereas those with severe COVID-19 are more likely to be treated non-operatively (Table 4). In other words, severe COVID-19 is a relative contraindication for emergency orthopaedic surgery. Patients with critical COVID-19 or those who are intolerant to operation or anesthesia are an absolute contraindication [7, 26, 28, 44].

Patient transfer to the operating room

The COVID-19 testing is difficult to get quickly enough in an emergency setting. All emergency patients are protected according to suspected or confirmed patients [5, 19, 28]. All medical personnel should take level-two protective measures, using the special transfer vehicle with disposable sheets to lead patients to transfer to the negative pressure operation room through a special channel and a special lift [5, 9, 13, 19, 28, 46, 47].

PPE in the operating room

The door of the operating room should be marked with a COVID-19 sign. Staff numbers should be minimized in the operating room [19, 23, 28]. Visitors to the OR should be restricted and medical personnel should not enter or leave the operating room to avoid interrupting the negative pressure. Level-three PPE is required in the operating room for all staff [5, 13, 48], except patrol nurses / runners who can use level-two PPE. The operating room must be in a state of negative pressure (- 5pa) before the operation [13, 23, 29, 46, 47]. The buffer room should be closed, and equipment should be minimized in the operating room. Staff wearing PPE in the operating room are forbidden to leave the operating room until the PPE has been removed and the operation has finished.

After the operation, the healthcare workers should first disinfect their hands, and then remove the PPE, discarding them in the double-layer yellow medical waste bag marked with COVID-19. It is necessary to wash hands with flowing water after removing protective gowns and gloves for at least two minutes.

Patients with non-generalized anesthesia should wear surgical masks throughout the operation [13, 15, 23, 47]. For patients under general anesthesia, a breathing filter should be installed between the anesthetic mask and the respiration loop, and a breathing filter should be installed at the inhalation and exhalation ends of the anesthesia machine respectively [13, 46, 47].

Operating room management

The high-efficiency particulate air (HEPA) filters must be in use and the room should have a negative pressure [13, 28, 46, 47]. After surgery, the room should be disinfected by spraying peracetic acid or hydrogen peroxide for more than two hours, and the laminar flow should be off and air supply closed. Sampling of the surfaces and air in the operation room should be tested by the hospital infection control team after the disinfection process. The next operation can be continued only after the monitoring results are qualified [7, 13, 47].

Prevention of surgical aerosol during surgery

Surgery using the electrocautery, ultrasonic bone knife, drill, pulsatile lavage and other powered equipment result in aerosolization of blood, bone, and tissue fluid [30]. COVID-19 is present in all body fluids and so will be present in this aerosol. Limitation of the use of these procedures will minimize the aerosol [30, 48]. Hirschmann et al. reported that orthopaedic surgery in particular to the lower limb, produces vast amounts of aerosols when high-speed power tools are used, and orthopaedic surgeons should use FFP2-3 or N95-99 respirator masks [30].

The ability for the aerosol to cause infection of the surgical team is unknown and dependent on the PPE worn by the surgical team. Smoke generated should be removed by an aspirator (note that suction also generates an aerosol) [48]. During the operation, normal saline for flushing should be minimised, splashing of the patient's body fluids should be avoided, and the residue of the fluid should be reduced as much as possible to prevent the pollution of the surrounding environment [30, 48]. The surgical team need to cooperate closely to prevent smoke from electrocautery, splashing of the patient's body fluid, and sharp instrument injury [13, 19, 23, 28].

Disinfection of surgical instruments

Surgical instruments that have been directly exposed to the patient's body fluid should be immediately scrubbed with 1000-2000mg/L chlorine containing preparation, and then placed into double-layer yellow medical waste bags, labeled with 2019-nCoV, and immediately inform the disinfection and supply center to take them away [7, 9].

Emergency pre-operative plan

The pre-operative plan should fully consider the complex situation of fracture management combined with COVID-19 status [44]. The aim is to comprehensively develop a personalized operation plan. The preoperative consent should inform the patients that the mild or moderate COVID-19 may aggravate to the severe and critical type, and there is no correlation with the operation [2, 5, 11, 44]. According to patient's condition, trauma, injury type, stability,

neurological function, medical equipment and technical conditions, the purpose of operation should be completed in a single approach or minimally invasive surgery as far as possible [33, 35, 38, 45]. The team should take measures to reduce the influence of time, trauma, hemorrhage and anesthesia on patients with COVID-19. Disposable surgical instruments should be used where possible and non-operative treatment should be strongly considered [7, 11].

Pelvic and acetabular fracture

For unstable pelvic fractures, non-invasive or minimally invasive measures such as pelvic belt or traction are preferred to maintain pelvic stability. For pelvic fractures with unstable hemodynamics, in principle, invasive operations such as external fixator or open surgery should not be performed, and limited fluid resuscitation treatment should be taken first [31-33]. Determine the location of bleeding timely with targeted treatment. If bleeding is excluded, the pelvic belt should be applied first. If hemodynamics is still unstable, surgeries included external fixator, gauze packing, angiography/embolization, and hemostasis can be used [5, 13]. Debridement should be done quickly and effectively to open pelvic fracture at an early stage and covered by vacuum sealing drainage, and Morel-Lavelle lesion should be vigilant [38-42].

Closed reduction should be performed timely for acetabular fracture with dislocation of hip joint. If difficult, emergency closed or open reduction in the operation room should be performed. If no contraindication, elective and definite operation for acetabular fracture can

be performed later. A single surgical approach [40, 41] with minimal trauma, the least possible complications and morbidity is preferred. In terms of internal fixation, the novel acetabular quadrilateral surface buttress plates [42, 43] were developed based on the concept of "frame and buttress" fixation and have good biomechanical properties, which may be a better choice for acetabular fractures involving quadrilateral surface.

Extremity fractures

Fractures of extremities with uncontrolled hemorrhagic shock and arterial damage, should have angiographic embolization, or an exploratory operation to repair or reconstruct vessels should be performed with simple fixation of the fracture. For patients with Gustilo II-III open fractures, thorough debridement should be performed, the fractured of limbs should be fixed with a combined external fixator, and important vessels and nerves of the limb should be repaired. If necessary, osteofascial decompression should be performed. An open wound with large skin defect should be closed by vacuum sealing drainage therapy. For patients with severe limb destruction, amputation should be performed when limb salvage is impossible [35, 36].

Postoperative management

Preoperative chest CT scan [5, 29,,44] is an important investigation for clinical diagnosis of COVID-19, as well as diagnosing lung injury caused by high-energy trauma. Nevertheless, nucleic acid testing for COVID-19 or virus sequencing should be done as soon as possible

after surgery. In addition to symptomatic and supportive treatment, complications, basic diseases secondary infection and thrombosis should also be controlled and treated; furthermore, early rehabilitation [33, 38-43] will help promote functional recovery and enable patients to return to a normal life as soon as possible.

The body temperature of patients should be monitored at least three times a day after operation. For patients with COVID-19, wound infection should not be judged only by the results of blood tests and body temperature [37]. Consider whether fever is caused by a wound infection or COVID-19 [44].

For patients with fractures, the bleeding risk of patients should be assessed correctly, and the prevention of deep vein thrombosis (DVT) should be carried out as early as possible. However, referring to Prevention and Control Protocols of Novel Coronavirus Pneumonia (Pilot version 7 modified) [5], DIC and multiple organ failure will occur in patients with critical COVID-19. Therefore, we suggest avoiding anticoagulant therapy [5, 44] to adult patients with critical COVID-19.

Management of elective surgery

In the pandemic area, the patients who do not need emergency surgery are admitted to the emergency buffer ward in single room isolation, and treated as suspected cases of COVID-19. After screening for COVID-19 (Table 3), COVID-19 negative patients can be transferred to the general ward in a single room, minimizing the number of family caregivers (at most 1 member) and forbidding other family members to visit [20, 22]. Caregivers should be

screened for COVID-19 [20, 25] (Table 3), and must be negative. Confirmed cases can be admitted in the same negative-pressure isolation ward with multiple persons. Severe or critical patients can be admitted to the intensive care unit as soon as possible [5, 44].

For patients undergoing a routine operation, if COVID-19 has been excluded, the surgery should be arranged with the normal treatment procedure according to the patient's priority; healthcare workers should take level 1 protective measures at least during surgery. For patients with surgery contraindicated in the early stage or other reasons such as conservative treatment failure, fear of hospitalization during the pandemic, etc., surgery can be performed according to treatment experience for delayed union [45, 49, 50], referring to the aforementioned protective measures. During the transition period, it is necessary to strengthen the monitoring and protection of patients and family caregivers [20, 22, 29]. If coughing and other symptoms suspected of COVID-19 occur, laboratory tests, chest CT scans and viral etiology tests should be performed immediately to rule out the possibility of COVID-19 infection [5, 20, 22, 29, 44].

Discharge and post-discharge management

For patients without COVID-19, discharge should be scheduled time after surgery to reduce cross-infection in the hospital [5, 15]. After being discharged from the hospital, an online outpatient clinic or telemedicine can be used to guide the patient's follow-up treatment [16-20, 22]. At the same time, it is necessary to continue to strengthen the monitoring and protection

of patients and family caregivers, and pay attention to the possibility of positive viral etiology test results in patients recovered from COVID-19 [5, 11, 25, 44].

Conclusion

Strict protection at every step in the patient pathway is important to reduce the risk of cross-infection during pandemic. Lessons learnt from our experience will help others to manage orthopaedic patients with COVID-19, to reduce the risk of cross-infection between patients and to protect healthcare workers.

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Table 1: Levels of PPE available

Protection Level	**Personal Protective Equipment(PPE)**
Level one	Disposable surgical cap Disposable surgical mask Work uniform Disposable latex gloves or/and disposable isolation clothing if necessary
Level two	Disposable surgical cap Medical protective mask (N95) Work uniform Disposable medical protective uniform Disposable latex gloves Goggles
Level three	Disposable surgical cap Work uniform Disposable medical protective uniform Disposable latex gloves Powered Air Purifying Respirator (PAPR) or Full-face respiratory protective devices*

* Due to the limited quantity of PAPR, N95/FFP2 mask and full-face respiratory protective devices are sometimes used instead.

Table 2: What PPE should be worn, and what steps done, by healthcare workers in different areas of the patient pathway (prehospital, emergency room, inpatient ward, OR, outpatients)

Sites	Prior to COVID-19 pandemic		During a COVID-19 pandemic	Specific advice / important knowledge
	No history of epidemic exposure	Epidemiological exposure history		
On-site first aid	Level one	Level two	Level two	Beware: all body fluids can contain COVID-19 virus (vomit, urine, blood, sputum). When in a pandemic, all patients are suspected of having COVID-19.
Ambulance	Level one	Level two	Level two	Beware: The ambulance environment receives a high level of aerosol. Negative pressure ambulances are preferred.
Emergency room	Level one	Level two	Level two	Test for COVID-19 ASAP.

				CT scan chest for all (appearances of COVID-19 are different to traumatic wet lung). Infection staff needed as part of the trauma team.
Patient transfer in hospital	Level one	Level two	Level two	Use special transfer, a special channel and a special lift.
Operating room	Level one	Level two	Level three	Severe COVID-19 is a relative contra indication to emergency orthopaedic surgery and criticial COVID-19 is an absolute contra indication. Level 3 PPE for all staff except runners who are level-two. Label door with COVID-19. Minimal staff numbers in the OR.

				Conversion of a positive pressure to a negative pressure of -5Pa should be confirmed prior to starting surgery. All patients should have masks if awake or exhaust filters if under general anaesthesia. Remove the smoke from electrocautery quickly. Reduce irrigation. Minimise splashing of the patient's body fluid. Hand disinfection is done before removing PPE.
Isolation wards	Level two	Level two	Level two	Beware: A high level of aerosol when performing high-risk procedures such as sampling from respiratory tract, intubation, tracheotomy, CPR, and etc., Level three PPE is required.
General wards	Level one	Level one	Level one	Pay attention to body temperature, respiratory symptom, and screening

				when necessary. Small probability that incubation period may be as long as 24 days.
Outpatients	Level one	Level two	Level two	Online outpatient clinic is preferred. Pay attention to body temperature, respiratory symptom and epidemiological exposure history. Pay attention to the possibility of positive viral etiology test results in patients recovered from COVID-19

Table 3: Screening item for all patients admitted during the epidemic period of COVID-19 [a]

Number	Screening item
1	The 2019-nCoV specific antibodies test
2	A chest CT scan
3	The 2019-nCoV nucleic acid test [b]

[a] All patients admitted during the epidemic period of COVID-19 and caregivers should be screened by the 2019-nCoV specific antibodies test, chest CT scan, and the 2019-nCoV nucleic acid test.

[b] The 2019-nCoV nucleic acid test can be screened twice for patients on admission if the first is negative.

Table 4: Clinical classifications of patients with a confirmed diagnosis of COVID-19 and indications for emergency surgery

Clinical Classifications	Clinical symptoms	Indication for emergency surgery
Mild	The clinical symptoms are mild and no pneumonia manifestations can be found in imaging.	No contra-indication due to COVID-19

Moderate	Patients have symptoms such as fever and respiratory tract symptoms, etc. and pneumonia manifestations can be seen in imaging.	No contra-indication due to COVID-19
Severe	Adults who meet any of the following criteria: respiratory rate ≥ 30 breaths/min; oxygen saturation ≤ 93% at a rest state; arterial partial pressure of oxygen (PaO2)/oxygen concentration (FiO2) ≤ 300 mmHg. Patients with > 50% lesions progression within 24 to 48 hours in lung imaging should be treated as severe cases.	Relative contraindication
Critical	Meeting any of the following criteria: occurrence of respiratory failure requiring mechanical ventilation; presence of shock; other organ failure that requires monitoring and treatment in the ICU.	Absolute contraindication