香 港 危 重 病 護 理 學 院
Hong Kong College of Critical Care Nursing (HKCCCN)
An Academy College of The Hong Kong Academy of Nursing (HKAN)
L G1, School of Nursing, Princess Margaret Hospital 232 Lai King Hill Road, Lai Chi Kok, Kowloon, HK
Website: www.hkcccn.org E-mail: hkcccn@yahoo.com

Local Practices on
Nursing Management of ICU Patients with COVID–19 in Hong Kong

I. Background & Objectives

A. Background

Coronavirus disease 2019 (COVID-19) was first identified in late December 2019 in the city of Wuhan, China. The infection continued to spread via human-to-human transmission throughout the country in China, but the source was unclear. Since then, it has become a fast-evolving outbreak in many countries leading to a pandemic ---- World Health Organization (WHO) declared the outbreak to be a Public Health Emergency of International Concern (PHEIC) on 30 January 2020, and recognized it as a pandemic on 11 March 2020. As of 23 July 2020, there were a total of 15 million cases confirmed globally; and more than 620,000 deaths across 188 countries/regions (B2b) (Johns Hopkins University, 2020). Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), the virus strain that causes COVID-19, is a systematic disease that primarily injures the vascular wall of the respiratory system. (C4) (Ricardo, 2020). It then leads to acute respiratory distress syndromes (ARDS), and if left untreated progresses to multiorgan failure. (B2a) (Marini & Gattinoni, L, 2020).

In the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID 19) report, 13.8% of the patients confirmed with COVID-19 were seriously ill and experienced respiratory distress. 6.1% of them were in critical conditions and developed severe respiratory failure and septic shock. These patients can deteriorate rapidly and eventually died of multiple organ failure. (B2b) (WHO 2020). This small portion of critically ill patients require intensive care management.

Hong Kong has its first confirmed case on 23 January 2020. Managing critically ill COVID-19 patients in Intensive Care Unit is a challenge to critical care nurses, as these patients have a very poor lung function, and they can develop exhaustion and severe hypoxemia very easily. Nurses need to take measures to improve patients' oxygenation, and at the same time, prevent from contracting such infection when providing close distance care.

B. Objectives

As COVID-19 is a novel and deadly disease worldwide, there are limited COVID-19 specific evidence-based findings to guide intensive care nursing practice.
The objectives of this document are primarily fourfold:

1. to have the consensus of critical care professionals in managing COVID-19 ICU
1. patients.
2. to serve as a reference to critical care nurses in the context of COVID-19.
3. to provide recommendations in managing COVID-19 patients.
4. to maximize the safety of critical care nurses in caring for COVID-19 patients.

II. Clinical Manifestations of Patients with Covid-19

A. Incubation period

The incubation period for COVID-19, the identifiable exposure to symptom onset, is on average 5-6 days, and can be up to 14 days (B2b, B2b, B2a) (WHO; CHP; Lauer et al, 2020). Most people developed symptoms within 2-14 days after exposure. Lauer et al (2020) reported that 97.5% of COVID-19 patients developed symptoms within 11.5 days of exposure.

B. Signs and Symptoms

Commonly reported signs and symptoms of COVID-19 include: cough (50%), fever of 38°C (43%) myalgia (36%), headache (34%), sore throat (20%), diarrhea (19%), nausea/vomiting (12%), and loss of smell/taste (10%). (C4) (Stokes et al, 2020). Bilateral patchy shadows or ground-glass opacity was the most common sign of radiological finding in both asymptomatic and symptomatic patients (89.6%) (B3b)(Zhang et al, 2020). Also, lymphopenia (75.4%) and eosinopenia (52.9%) were observed in most patients. Significantly higher levels of D-dimer, C-reactive protein, and procalcitonin were associated with severe patients compared to non-severe patients. There are, however, 40-46% who test positive for COVID-19 are asymptomatic or experience mild minor symptoms. (C4, B2a) (Oran et al, 2020; Lauer et al., 2020). These asymptomatic infected patients have shown subclinical lung abnormalities in computed tomography. (C4) (Oran et al., 2020).

C. Severity of the illness

The spectrum of illness can range from asymptomatic infection to severe pneumonia with acute respiratory distress syndrome (ARDS) and even death. In a summary of 72,314 persons with COVID-19 in China, 81% of cases were reported to be mild, 14% were severe, and 5% were critical. (B2a) (Wu & McGoogan, 2020). Centers for Disease Control and Prevention (CDC) further classified the severity of the illness into three categories:

1. Mild to moderate: mild symptoms up to mild pneumonia
2. Severe: Dyspnea, hypoxia, or >50% lung injuries on imaging
3. Critical: Respiratory failure, shock, or multiorgan system dysfunction

D. Risk factors for severe illness

Increasing of age is the most important risk factor of the severity of COVID-19 (B2a, B2b, B2b) (Docherty et al. 2020; WHO, CHP), and it was a strong predictor of the mortality in a recent study. (B2a) (Docherty et al 2020). Other risk factors include: chronic cardiac disease (31%), diabetes (21%), pulmonary disease (18%), and chronic kidney disease (16%), or compromised immune system have association

with the mortality and the acuity level of care among COVID-19 patients.

Children appear to be less susceptible to COVID-19 infection. According to the Report of the WHO-China Joint Mission on Coronavirus Disease 2019(B2a), disease in children is relatively rare and mild with approximately 2.4% of the total cases reported amongst aged less than 18 years. In United States, among 99.6% confirmed COVID-19 cases for which patient age was known, 1.7% occurred in children aged less than 18 years, 76% were aged 18-64 years (B2b) (CDC COVID-19 response team, 2020 April). Similar in Italy, 1.2% of COVID-19 cases were reported among children aged less than 18 years (B3a) (Livingston & Bucher, 2020)

III. Patient Diagnosis & Specimen Collection

A. Introduction

Since December 2019, there has been over 1000 confirm cases in Hong Kong till early May 2020. Active community transmission is observed and it is suggested that the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is highly contagious.

People who are infected will experience common flu-like respiratory symptoms such as cough and fever, some of them are even asymptomatic. Diagnostic testing therefore plays a vital role in early detection of patients. A rapid laboratory testing of SARS-CoV-2 is crucial for the implementation of effective containment strategies and prevention of further viral transmission. An accurate diagnostic test result is also important for timely clinical management. Early diagnosis and intervention are suggested to improve patients' prognosis and save lives.

B. Patient Diagnosis

Reverse transcription polymerase chain reaction (RT-PCR) is a common diagnostic test for COVID-19. (D5) (Centers for Disease Control and Prevention [CDC], 2020; Koh & Cunningham, 2020; Lippi et al., 2020; WHO, 2020). It detects the presence of SARS-CoV-2 ribonucleic acid (RNA). A positive identification of SARS-CoV-2 RNA in the sputum or nasopharyngeal specimens is considered as confirmation of the disease. A study in Hong Kong also reported that there are 11 out of 12 COVID-19 patients were tested positive by viral culture in their self-collected saliva specimen, suggesting that deep throat saliva is a potential specimen for diagnosing the SAR-CoV-2. (C4) (To, et al., 2020).

In Hong Kong, according to the clinical information prepared by the Chief Infection Control Officer (CICO) Office in Hospital Authority in 2020, respiratory specimens (such as sputum, tracheal aspirate, nasopharyngeal swabs and aspirate) will be sent to laboratory for SARS-CoV-2 RT-PCR tests. If the preliminary result is positive, the specimen will be retested and sent to the Public Health Laboratory Services Branch (PHLSB) of the Centre for Health Protection (CHP) for further confirmation. Although RT-PCR is widely used in diagnostic virology, it is not 100% accurate and false positive or false negative result can be occurred. A negative test result indicates that the viral RNA was not identified in the specimen. However, it could be a false negative result due to several reasons, such as the level of viral RNA is below the detection limit, or degradation of viral RNA during transport and storage. (D5) (Koh & Cunningham, 2020). Therefore, repeated diagnostic testing should be considered if the patient is highly suspected of COVID-19 infection. (D5) (WHO, 2020).

Titers of SARS-CoV-2 antibodies such as IgG and IgM have been suggested to use for diagnosing acute infection. A study indicated that around 40-50% patients develop an antibody response to SARS-CoV-2 infection after 7 days, and the majority by 14 days. The seroconversion rate and the antibody levels increased in 7 to 14 days. (C4) (Zhao, et al., 2020). Nevertheless, a positive antibody test results can also indicate a previous infection with SARS-CoV-2. Thus, testing antibody titers is helpful for surveillance, prediction of disease outcome and epidemiological investigation, but not for early diagnosis. RT-PCR for virus detection still remains the top priority method of choice.

C. Specimen Collection

An early COVID-19 diagnostic testing is recommended for suspected case regardless of the time of symptom onset. A lower respiratory tract specimen such as a lower respiratory tract aspirate in intubated patient or bronchoalveolar lavage (BAL) sample in patient who required bronchoscopy is always preferred as it has a highly diagnostic value for these patients who are clinically indicated such as signs of pneumonia. Collecting and testing upper respiratory tract specimens such as nasopharyngeal swabs (NPS) or nasopharyngeal aspirate (NPA) is also recommended in particular for patients only have upper respiratory infection (URI) symptoms. (D5) (CDC, 2020; CICO Office, 2020; Koh & Cunningham, 2020; Loffelholz & Tang, 2020; WHO, 2020).

Regarding the local practice in Hong Kong, suspected cases could have NPS and throat swab for RT-PCR (SAR-CoV-2) collected in Airborne Infection Isolation Room (AIIR) with negative pressure and at least 12 air changes per hour (ACH)). In case of AIIR exhaustion or no AIIR available at AED or ward setting, NPS and throat swab could be collected in an adequately ventilated single room with at least 6 ACH and the use of portable High-efficiency particulate air (HEPA) filter unit such as the "IQ Air" with in-built HEPA Filter. (D5) (CICO Office, 2020). For outdoor and community setting, the procedures could be performed in an environment with good natural ventilation. However, care must be taken to minimize the chance of aerosolization. Although collection of NPA or NPS is not an aerosol generating procedure (AGP), the procedure is theoretically at risk of dispersal of infectious respiratory droplets. Nurses require close contact with the suspected or confirmed COVID-19 patient during specimen collection. He / She should observe proper infection control and hand hygiene guidelines. To reduce the risk of virus transmission during specimen collection, nurses are recommended to have Personal Protective Equipment (PPE) including N95 respirator, googles/ face shield, isolation gown and disposable gloves to protect them from droplets, contact and airborne transmission. (D5) (CDC, 2020; CICO Office, 2020). The PPE standard remains the same for NPS taking in either AIIR or non-AIIR.

For patients with symptoms of productive cough, sputum should be collected and tested for SARS-CoV-2. However, induction of sputum is not recommended by WHO and CDC because the process may increase aerosolization and risk of transmission. In the Enhanced Laboratory Surveillance Scheme for COVID-19 in Hong Kong, patients who have respiratory symptoms are educated to save early morning deep throat saliva at home for SARS-CoV-2 PCR test. (D5) (CICO Office, 2020). This is also an easy and non-invasive measure for specimen collection.

As fecal shedding has been demonstrated from some patients, stool specimen is suggested for suspected patient who presents with diarrhea. (D5) (CICO Office, 2020). It is found that some patients can still test positive for fecal pathogenic nucleic acid after the negative results of respiratory specimens. (C4) (Xing, et al., 2020). Additional specimens such as blood and any other sites if appropriate could be considered for further testing.

The quality of specimens can be affected by several steps including specimen collection, transport, and storage. (D5) (Lippi et al., 2020). Proper collection of specimens and getting adequate specimens as well as safe handling of specimens enables earlier diagnosis of the coronavirus disease, and appropriate management can be given at the earliest possible time. A specimen that is wrongly collected (e.g. use of wrong specimen bottles, inappropriate collection technique, contamination, etc.) may lead to false negative test result. To increase test sensitivity, nurses have the responsibility to collect quality specimens from the correct patient according to local guidelines. Sample quality depends greatly on the operation of the collectors, especially the upper respiratory tract and sputum samples.

D. Conclusion

Early diagnosis and isolation are important in combating COVID-19 pandemic. SARS-CoV-2 can be found in upper or lower airway, blood and stool. Appropriate sampling for prompt detection of disease is vital and it’s one of the important tasks for critical care nurses. The diagnostic results depend on factors such as the sample types, the sample quality, and the sample collection technique. As COVID-19 is a highly contagious disease, nurses have the responsibility to collect the specimens fast and appropriately to get an accurate and interpretable results to enable early and proper patient management. Besides, it is crucial for nurses to have proper personal protection to avoid cross infection.

IV. Nursing Management of ICU Patients with COVID-19 in Hong Kong

A. Isolation Ward Design, Healthcare Providers, Isolation Room Setup and Equipment

1. Isolation Ward Design

1.1. Airborne Infection Isolation Room (AIIR) with negative pressure at least 12 air changes per hour (ACH). (A1a) (Agarwal, et al., 2020; CDC, 2019; CDC, 2020; CICO Office, 2020; National Center for Disease Control, 2020)

1.2. AIIR en-suit with toilet facility, hand washing facility and alcohol-based hand rub (ABHR). (A1c) (CDC, 2019; National Center for Disease Control, 2020, CICO Office, 2020). In Hong Kong, toilet facility is not a standard provision for all ICUs.

1.3. Double-doors design with interlocking system, and ante-room outside the AIIR. (A1c) (Agarwal, et al., 2020)

1.4. Negative pressure differential monitoring B2c (Agarwal, et al., 2020; CDC, 2020)

1.5. Ward layout should be divided into clean zone and dirty zone, nursing station and changing room, and dedicated areas for donning and doffing of personal protective equipment (PPE). (D5) (National Center for Disease Control, 2020; Yen et al., 2006).

There are strong evidences and recommendation that airborne infection isolation room (AIIR) with negative pressure at least 12 air changes per hour (ACH) should be adopted, especially for isolation of confirmed or suspected COVID-19 patients (A1a) (Agarwal, et al., 2020; CDC, 2019; CDC, 2020; CICO Office, 2020; National Center for Disease Control, 2020).

According to CDC guidelines and recommendations, known or suspected COVID-19 patient should be placed in a single-person airborne infection isolation room (AIIR) with door closed. Also, AIIR should be reserved for patients who will be undergoing aerosol generating procedures. AIIRs are single-patient rooms at negative pressure relative to the surrounding areas, and with a minimum of 12 air changes per hour (ACH) (A1c) (CDC, 2020). In addition, facilities should monitor and document the proper negative pressure function of these rooms (B2c) (Agarwal, et al., 2020; CDC, 2020).

National Centre for Disease Control (2020) also recommended that AIIR should have double door entry with changing room and nursing station. Additionally, the AIIRs should en-suit with toilet facility, hand washing facilities and hand hygiene

supplies such as alcohol-based hand rub (ABHR) (1Ac) (CDC, 2019; National Center for Disease Control, 2020, CICO Office, 2020).

Agarwal, et al. (2020) (A1c) recommended that a negative pressure room should have a minimum of 12 ACH and an anteroom outside the negative pressure room.

Little evidence on ward layout of an isolation ward design for COVID-19 patients. Adopted from SARS episode experience in 2003, it is recommended that ward layout should be divided into clean zone and dirty zone (patient area), dedicated areas for donning and doffing of personal protective equipment (PPE), with nursing station and preferably changing room facility (D5) (National Center for Disease Control, 2020; Yen, et al., 2006).

2. Healthcare Providers (HCP)

2.1. All healthcare staff involved in COVID-19 patient care should be well trained in infection prevention and control measures, including the use of relevant PPE.

Guidelines and research highly recommended that healthcare staff who involved in care of COVID-19 patients should have training or be well trained in infection prevention and control measures (B2c) (Agarwal, et al., 2020, Centers for Disease and Control, 2020; Liew, Siow, MacLaren & See, 2020; National Center for Disease Control, 2020).

CDC (2020) (B2c) recommended that healthcare providers should be educated, trained and have practiced the appropriate and correct use of PPE prior to caring the COVID-19 patients (including proper donning and doffing of PPE). Training should include prevention of contamination of clothing, skin and the environment.

National Centre for Disease Control (2020) (B2c) recommended that all healthcare staff involved in patient care of COVID-19 patients should be well trained in the use of PPE (donning and doffing and proper disposal of PPE), hand washing, and waste management.

Agarwal, et al. (2020) (B2c) recommended that healthcare providers who will participate in the care of COVID-19 patients including doctors and nurses require the training on infection prevention and control training.

Liew et al. (2020) (B2c) recommended and emphasized the importance of education and re-education on PPE for healthcare providers, especially for isolation team.

Based on local hospital policy in Hong Kong, the Chief Infection Control Office [CICO Office, 2020] (B2c) also emphasized to conduct refresher training or drill exercise so as to reinforce infection control measures for healthcare providers.

2.2. Segregation of teams with dedicated staff to care COVID-19 patients. (D5) (CDC, 2020; Liew, Siow, MacLaren & See, 2020; National Centre for Disease Control, 2020)

CDC (2020) (D5) recommended that as a measure to limit healthcare provider (HCP) exposure and for the sake of conserving PPE, facilities could consider designating HCP to care for patients with known or suspected COVID-19 or assigning HCP only for these patients during their shifts.

National Centre for Disease Control (2020) (D5) also recommended that doctors, nurses and paramedics posted to isolation facilities need to be dedicated and not allowed to work in other patient-care areas.

Liew, Siow, MacLaren & See (2020) (D5) recommended a dedicated roster to segregate "clean" and isolation teams, and to provide for stand-bys.

Phua et al. (2020) (D5) also recommended segregation of team to limit unprotected exposure of all team members to infected patients or colleagues, and resultant loss of staff to illness, medical leave, or quarantine.

In Hong Kong, there exists no standard duration of break which was proved to have an evidence on staff protection. It is subject to the policy of individual organization.

2.3. Preferably, deploy a patrol nurse for on-site inspection and monitoring. (D5) It is only an expert opinion and a current recommended practice in isolation ward in Hong Kong hospitals since SARS episode in 2003.

3. Isolation Room Setup and Equipment

3.1. Inside AIIR

3.1.1. Designated patient devices and physiological monitoring devices. (B2c) (CDC, 2020; National Center for Disease Control, 2020)

3.1.2. Essential equipment includes ventilator with scavenging system for intubated patients, infusion pump and syringe pump, oxygen flowmeter, sharp container. (D5) In Hong Kong, based on the experience of SARS episode in 2003, ideally, it is advisable to incorporated an efficient closed

circuit scavenging system into ventilator exhalation port for infectious patient requiring mechanical ventilation. (B2c) (Tang & Chan, 2004; Yam, Chen & Zhong, 2003). Some centers add two high-efficacy filters i.e. one to the end of expiratory limb, one before the Y-piece.

3.1.3. Laundry bag and lidded rubbish bin; designated floor mop and measuring jar. (D5) (National Centre for Disease Control, 2020)

3.1.4. Hand washing facilities and alcohol-based hand rub (ABHR). (A1c) (CICO Office, 2020)

3.1.5 Bedpan liner and high-absorbency gel (B2c) (CICO Office, 2020)

3.1.6. Telephone or other method of communication. (D5) (National Centre for Disease Control (2020).

3.1.7. Item/ equipment inside AIIR should be kept minimal. (D5) (National Centre for Disease Control (2020).

3.1.8. Use disposable items when those items cannot be cleaned or disinfected properly. (D5) (National Centre for Disease Control, 2020).

3.1.9. Sodium hypochlorite solution 1,1000ppm should be used for surface disinfection for reusable equipment after patient use. (B2c) (CICO Office, 2020)

It is highly recommended that designated patient devices should be adopted for COVID-19 patients (D5) (CDC, 2020; National Center for Disease Control, 2020). CDC (2020) recommended that dedicated medical equipment should be used when caring for patients with known or suspected COVID-19.

Non-critical patient-care equipment (e.g. stethoscope, thermometer, blood pressure cuff, and sphygmomanometer) should be designated to COVID-19 patients. Avoid sharing of equipment, but if unavoidable, ensure that reusable equipment is appropriately disinfected between use by patients. It also recommended that a touch-free waste disposal bin, puncture-proof container to be used for sharp disposal, proper cleansing and supplies, telephone or other method of communication in the isolation room or area to enhance the communication (D5) (National Centre for Disease Control, 2020).

Based on local hospital policy in Hong Kong, the Chief Infection Control Office [CICO Office, 2020] (D5) also emphasized the use of disposable items when those items cannot be cleansed or disinfected properly. If reusable equipment were used, sodium hypochlorite solution 1,1000ppm should be used for surface disinfection after patient use. In addition, it is recommended that liner bag can be used as

surrogate for urinal and bedpans, and use of high-absorbency gel to solidified the content and discarded as clinical waste after use.

3.2. Ante-room

3.2.1. Place touch-free lidded rubbish bin for de-gowning purpose. (D5) (National Centre for Disease Control, 2020).

3.2.2. Mirror for doffing of PPE. (B3b)

3.2.3. Hand washing facility and alcohol-based hand rub. (B2c) (CICO Office, 2020; National Centre for Disease Control, 2020)

National Centre for Disease Control (2020) (D5) recommended that touch-free lidded rubbish bin for de-gowning purpose. Hand washing facility and alcohol-based hand rub should be placed at ante-room (B2c) (CICO Office, 2020; National Centre for Disease Control, 2020).

Expert opinion recommended to place a mirror at ante-room for doffing purpose.

3.3. Outside AIIR

3.3.1. Post infection control signage and poster (airborne, droplet and contact Precautions in addition to standard Precautions) outside isolation room door. (D5) (National Centre for Disease Control, 2020).

3.3.2. Provide gown up area and stock for PPE. (D5) (National Centre for Disease Control, 2020).

According to National Centre for Disease Control (2020) (D5), signage should be posted outside the isolation room door. Also, PPE should be stock outside the isolation room or areas.

Chief Infection Control Officer (CICO) Office (2020) (B3b) recommended that airborne, droplet and contact Precautions in addition to standard Precautions should be adopted in caring COVID-19 patients.

B. Infection Control Policy

1. Personal Protective Equipment (PPE) Standard at Different Level

1.1 Infection control precautions

Implement Standard precaution, Droplet and Contact Precautions in addition to Standard Precautions. (B2c) (Lake, 2020). According to the studies on human

coronaviruses (SARS and MERS), the transmission routes are mainly through respiratory route or via contact with infectious secretions (B2c) (Lake, 2020).

Current studies show that COVID-19 is spreaded by human-to-human transmission (B2c) (Hamid et al, 2020, Lake, 2020 & World Health Organization a, 2020), through direct contact or by droplet route. Previous study on SARS-CoV showed fomite could spread via contaminated surfaces (B2c) (Lake, 2020). The study reports SAR-CoV-2 virus could be transmitted through aerosols and direct contact with infected persons by the resuspension on the PPE and on the floor in the staff room. Therefore, airborne precaution should be implemented, especially when performing aerosol-generating procedure (AGPs) (B2c) (Lui et al, 2020).

1.2. World Health Organization (WHO)'s recommendations on PPE

The appropriate PPE are medical mask, an eye protection or face-shield for avoiding mucous membranes contamination; long-sleeved gown and gloves; shoes covers, coverall and apron are not required during routine care and wear N95 respirator for AGPs is required (D5) (WHO, 2020a).

Masks: Wear surgical mask (areas with no contact, outside patient's room) or wear N95 Respirator (for routine patient care and aerosol generating procedures, AGPs) (A1a) (Bartiszko, et al, 2020); (B2c) (Guzman, 2020); (C3b) (Seto et al, 2003); (D5) (CHP 2020b; HA 2020 & WHO 2020a,).

Eye Protection: Goggles/face shield for handling of suspected/confirmed cases, or in anticipation of large amounts of splashes of blood, body fluids, excretions or secretions (eg AGPs, Trauma case etc. (B2c) (Xia et al, 2020 & Xie et al, 2020); (D5) (CHP 2020b; HA 2020 & WHO 2020a).

Gown: Two levels of disposable gown: Advancement of Medical Instrumentation (AAMI) level 1 and level 3 are provided by Hospital Authority (HA). AAMI Level 1 for low risk of contamination with bodily fluid exposure; Level 3 for direct contact with blood, body fluids and/or other potentially infectious materials (B2c) (Xia et al,

Gloves: Wearing gloves whenever contacted with patient and patient's environment (B2c) (Xia et al, 2020 & Xie et al, 2020); (D5) (CHP 2020b; HA 2020 & WHO 2020a,).

Caps (optional) and Shoe covers: can be used during participated in AGPs or providing direct care. Shoe covers is not recommended (D5) (CHP 2020b; HA 2020 & WHO 2020a,).

In Hong Kong, according to Center of Health Protection (CHP) and Hospital Authority (HA) guidelines, surgical mask should be worn outside patient's room and

non-patient's area and N95 used for routine patient care (CHP, 2020b & HA, 2020) (D5). Face mask wearing is a crucial factor to prevent HCWs contact with the infection, a retrospective study done in 2003 reported the surgical mask and N95 masks were both effective in significantly reducing the risk infection (Seto et al, 2003) (C3b). A report shows the medical masks can provide similar protection as N95 respirators that against with vial respiratory infections during routine care and non-AGPs (Bartiszko, et al, 2020) (A1a). A Study suggests the high efficiency filtration respiratory (N95 respiratory) to prevent the SARS-CoV-2 containing particles <2.5um further reach deep into the lungs may cause infection (Guzman, 2020) (D5). Recent studies find out the SAR-CoV-2 virus can be found in tear samples in COVID-19 patients with or without conjunctivitis, they are also believing that COVID-19 can be transmitted through secretions and mucosa membranes, therefore the face-shield, goggles and long sleeved gown should be worn to protect skin and mucus tissues when contacting patients with COVID-19 virus (Xia et al, 2020 & Xie et al, 2020) (B2c).

1.3 Proper donning and doffing

Perform donning and doffing of PPE properly in the designated area (B2c) (Suen et al ,2018) (D5) (CHP, 2020a; HA, 2020 & WHO, 2020a,). In this situation, donning and doffing is the practice of putting on and removing the protective wears and equipment before and after entering the isolation areas.

A local study compared the three sets of PPEs (PPE for Ebola, Coverall and PPE for AGPs) revealed that there stood the higher chance of self-contamination on anterior neck, arms, working clothes, clogs and the possibility of environmental contamination during doffing the PPE after AGPs (Suen et al ,2018) (B2c). The proper donning and doffing of PPE procedures are reinforced as to minimize self-contamination. (CHP 2020a; HA, 2020 & WHO, 2020a) (D5).

1.4 Change PPEs in-between patient care

Staff should change gloves, gowns and practice hand hygiene before and after each patient's contact to minimize the further spread of infection. (HA, 2020 & WHO, 2020a) (D5).

1.5 Hand hygiene

Perform hand hygiene frequently for at least 20 seconds, wash hands with soap and water for visible dirt or soiled with blood, excreta and/or body fluid, after using

toilet or changing the diapers. Use 70-80% alcohol-based hand rub is an alternative when hands are not visibly soiled (A1b) (Girous et al, 2002; Sickbert-Bennett, 2005); (D5) (CHP, 2020a & HA, 2020). A study reports that perform hand hygiene with the alcohol-based handrub for about 30 seconds has greater reduction of bacterial contamination than conventional handwashing. (A1b) (Girous et al, 2002) Another study suggests the efficacy of alcohol-based handrubs reduced after 10 episodes, effective hand hygiene is best achieved by physical removal with a soap or tap water alone. (A1b) (Sickbert-Bennett, 2005). In Hong Kong, as refers to the recommendations of CHP and HA, the hand hygiene should be performed at least 20 seconds with the use of alcohol-based hand rub and hand washing when visible dirt noted. (D5) (CHP, 2020a & HA, 2020)

1.6. Fit test (D5) (CDC, 2020; CHP, 2020b & HA, 2020)

Performs fit test for selection of a suitable type, model and size of respirator for individual prior initial use of N95 respirator to provide sufficient protection to HCWs. The seal check should be performed to ensure the respirator has completely sealed on user's face (D5). (CDC, 2020 & HA, 2020).

1.7. Avoid touching the N95 respirator and eye protection with hands (B2c) (Kwok, Y L A et al, 2015); (D5) (HA, 2020)

Self-contamination can be increased by touching the PPEs frequently. An observational study about the unintentionally touching the facial areas, they observed 26 medical students with 2,346 touches over 240 minutes and found 56% face touches involved non-mucosal areas and 44% involved contact with mucosal membranes which involved mouth, nose and eyes Health care workers are advised to avoid touching the N95 respirator and eye protection with hands to minimize the self-contamination related to unintentional touches (D5) (HA, 2020).

1.8. Use N95 respirator or use higher level Powered Air-Purifying Respirator (PAPR) when performing Aerosol Generating Procedures (AGPs) with proper disposal and disinfection. (D5) (CHP, 2020b; Guzman, 2020 & HA, 2020).

A study and guidelines recommend to use N95 respirators during AGPs. (D5) (CHP, 2020b; Guzman, 2020 & HA, 2020). PAPR can be an alternative and provides a higher protective factor than N95 respirators, but there exists no conclusive evidence of decrease of airborne transmission, as to prevent contamination and

cross infection, users should perform proper doffing and disinfection procedures. (D5) (Wong et al, 2020).

2. Equipment Preparation and Disinfection

2.1 Single-use or dedicate individual equipment for the patient. (D5) (CDC, 2020a; CHP, 2020a & WHO, 2020c)

2.2 Clean the patient's environment (especially high touch areas) with 1 in 49 diluted household bleach to clean at least twice daily and/or visibly soiled. (A2b) (Kampf, et al, 2020b); (B2c) (Liu et al, 2020); (D5) (CHP, 2020a & WHO, 2020c)

2.3 Use 1 in 4 diluted household bleach to wipe the areas that contaminated by body fluids (blood, secretions, vomitus and excretions) from the suspected/confirmed cases. (D5) (CHP, 2020a & WHO, 2020c)

2.4 Use 70% alcohol to disinfect the metallic surface. (A2b) (Kampf, et al, 2020b); (D5) (CHP, 2020a)

2.5 Perform terminal disinfection upon patient discharge. (D5) (WHO, 2020c)

2.6 Clean and disinfect shared equipment before reuse. (D5) (WHO,2020c)

The existing cleaning and disinfection procedures should be followed consistently and correctly (WHO, 2020c) (D5). The single-use and disposable equipment should be provided to those suspected and confirmed patients (WHO, 2020c, CDC, 2020a and CHP, 2020a) (D5). After patient discharge, performs terminal disinfection is recommended (WHO, 2020c) (D5). Therefore, the cleaning and disinfection procedure should be done at least daily to minimize the risk of virus staying on the surface (D5) (WHO, 2020c). CHP suggests to perform cleaning at least twice daily or more (D5) (CHP, 2020a). Another study demonstrates the reduction of viral loading in de-gowning area and the floor of patient's area with frequently use of chlorinated disinfectant spray before doffing and prolonged operation time of indoor air purifiers and 3% hydrogen peroxide cleaning weekly (B2c) (Liu et al, 2020). This result supports the importance of sanitization in reducing the airborne SARS-CoV-2 in high risk areas.

Recent studies point out the SAR-COV-2 virus can remain infectious up to hours to days (Neeltje v D, et al, 2020) (A1b) mentioned: -SARS-CoV-2 is still viable in aerosols for 3 hours; up to 72 hours on plastic surface; detected after 48 hours on stainless steel; and at 24 hours on cardboard.

WHO recommends the disinfection to the small surface area and the dedicated items with 70% ethyl alcohol and sodium hypochlorite at 0.1% (1000ppm) for surface disinfection and 0.5% (5000ppm) for blood or bodily fluid contaminated surface (WHO,2020c) (D5). A review study on human coronavirus (MERS and SARS-CoV) concluded that exposed the disinfecting surface for 10 minutes with 0.01% sodium hypochlorite or 70% ethanol were significantly reducing coronavirus infectivity (Kampf, et al, 2020b) (A2b). CHP suggests using of 70% alcohol to disinfect metallic surface and diluted household bleach to disinfect the patient's environment and body fluid contaminating surfaces (CHP,2020a) (D5). For respiratory therapy equipment requiring high-level disinfection, central reprocessing is preferred. It's subject to local hospital policy.

3. Handling of Blood, Body Fluid, Excreta and Dead Body:

3.1 Put on the PPE prior handling blood, body fluid, excreta and dead body. (D5) (CHP, 2020a, HA, 2020 & WHO, 2020c)

There is no evidence demonstrates the transmission of COVID-19 virus by the direct, unprotected human contact during the handling of health-care waste (WHO, 2020c) (D5). The clinical waste is produced during patient care, including those with confirmed COVID-19 infection is considered to be infectious, HCWs should wear PPE when handling it (CHP 2020a & WHO, 2020c) (D5).

3.2 Disinfect the blood, body fluid and excreta contaminated area (refer to item 2 for disinfection details).

3.3 All wastes (including diapers, removed dressing materials etc.) from suspected or confirmed patients are classified as clinical waste. (D5) (CHP 2020a & WHO 2020c)

3.4 Use bedpan washer to clean and thermal disinfect the urinals and bedpans. (B2c) (Kampf et al, 2020a); (D5) (HA, 2020)

There is limited data demonstrating the effectiveness of thermal disinfection. A report reviewed 10 studies and found out the effective temperature for reducing coronavirus infectivity are 60°C for 30 minutes, 65°C for 15 minutes and 80°C for 1 minute (Kampf et al, 2020a) (B2c). The used urinals and bedpans are recommended to be cleansed by bedpan washer with thermal disinfection process (HA, 2020). (D5).

3.5 Handling and disposal of dead body according to Category 2 (Yellow label) with appropriate PPE, the dead body should be bagged in a robust and leak-proof transparent plastic bag (not less than 150um thick) and zippered closed, after

that wrapped with mortuary sheet or placed into an opaque body bag. Then wiped the outer body bag with 1 in 4 diluted household bleach and allow to air dry. (D5) (CHP, 2020a; Department of Health, 2014 & HA, 2020)

In Hong Kong, the guidelines on dead body handling has been revised and signified COVID 19 as category 2. The special precautions to handle the dead body are instructed according to the guidelines. (D5) (CHP, 2020a; DH, 2014 & HA, 2020). There exists limited data to provide evidence of possible transmission through contact with dead body. It's suggested to use leak-proof plastic bag for storage of dead body when there is body fluid leakage. (D5) (WHO, 2020b).

4. Prevention of Spread of Infection through Social Distancing in ICU:

4.1 Social distancing of staff during, meal time/rest day. (B2c) (Kwok et al, 2020; Setti et al, 2020); (D5) (CHP, 2020c & WHO, 2020a)

4.2 Avoid social gathering. (D5) (CHP, 2020c & WHO, 2020a)

4.3 Stay in a well-ventilated single room. (D5) (CHP, 2020c & WHO, 2020a)

4.4 Reduce direct face to face contact. (D5) (CHP, 2020c & WHO, 2020a)

WHO and CHP recommend to maintain social distancing, avoid social gathering and face-to-face contact, as to prevent the spread of infection and stay in a well-ventilated room (D5) (CHP, 2020c & WHO, 2020a)

A research demonstrates that wearing masks and staying away from crowded areas can protect from infection (Liu et al, 2020) (D5). A study points out in the early phase of COVID-19 epidemic in Hong Kong is associated with the pre-symptomatic transmission and delayed containment, that leads to further symptomatic transmission, therefore the sustainable physical distancing is recommended. (B2c) (Kwok et al, 2020). For the distance measures, at least 1 meter and 1.5 meters apart are suggested. (D5) (CHP, 2020c & WHO, 2020a). Another report concludes the distance among persons could be 2 meters with them wearing face masks. (B2c) (Setti et al, 2020)

5. Staff Travel, Occupation, Contact Cluster (TOCC) and Quarantine Arrangement

Staff have sent to quarantine if he/she had travel history in the last 14 days and identified as lose contacts. (Close contacts defined as those cared for the confirmed case without appropriate PPE for the procedures). (B2c) (Wang, 2007; Li et al, 2020)

A study demonstrates the quarantine of high-risk persons was an effective measure to prevent the spread of SARS in Taiwan. (B2c) (Wang, 2007). Another study on COVID-19 infection provides the important evidence to support a 14-day medical observation period or quarantine for exposed persons. (B2c) (Li et al, 2020). WHO recommended the contracts of patients with laboratory-confirmed COVID-19 be quarantined for 14 days from the last exposure to the patient. (D5) (WHO, 2020d). The Department of Health of Hong Kong SAR started to issue quarantine orders under the Prevention and Control of Disease Regulation (Cap.599A) for compulsory home quarantine to people arriving in Hong Kong who have been to any one of all overseas countries/territories in the past 14 days, regardless of whether they are Hong Kong residents (D5) (HKSAR, 2020).

6. Transfer of Infectious Patient

6.1 Wear appropriate PPE when handling patients (D5) (HA, 2020 & WHO, 2020a).

6.2 Provide surgical mask to patients during transportation if not contraindicated) (D5) (HA, 2020 & WHO, 2020a).

6.3 Identify the route of patient's transportation and communicate with receiving ward/department before leaving the ward (D5) (HA, 2020 & WHO, 2020a).

6.4 Arrange personnel to disinfect the patient's route afterwards (D5) (HA, 2020 & WHO, 2020a).

WHO suggests minimizing the unnecessary transportation of patients out of their room or accommodation. (D5) (WHO, 2020a). If medically necessary for transportation, the transport routes should be planned to minimize exposure for staff, other patients and visitors. Medical mask should be provided to the patient if no contraindication (for example on mechanical ventilation). HCWs who serve as escorts must wear appropriate PPE during the transportation. The receiving department must be notified as early as possible before the patient's arrival. After the transportation, clean and disinfect the patient contacted areas. (D5) (HA, 2020 & WHO, 2020a)

C. Airway Management & Oxygenation

1. Policy for Performing Intubation

We recommend to observe airborne precautions. It is mandatary that proper hand hygiene and donning of personal protective equipment must be followed in performing intubation. This aerosol-generating procedure should be performed in an airborne infection isolation room (AIIR). Double gloving throughout the whole procedure could protect and minimize spreading contaminant to the surroundings. (D5) (Chang et al, 2020). However, double gloving practice may not be applied to all clinical settings and it depends on decision from individual department.

Intubation should be considered if patient's respiratory condition is anticipated to be deteriorating The procedure is suggested to be performed by expert who is specialized in airway management, such as, Anaesthetist, Intensivist, and Emergency physicians. During the procedure, it is suggested to avoid bag mask ventilation as far as possible; and optimizing preoxygenation with non-aerosol-generating means.

Methods: Sniffing position by flexing the neck and extending the head at the atlanto-occipital joint, BURP (backward-upward-rightward pressure) maneuvers on the larynx, use of exhalation filter between the mask or endotracheal tube and the bag with PEEP (Positive End Expiratory Pressure) valve (optional); and airway adjunct. (D5) (Cheung et al., 2020). However, we should also consider if trial period of other non-invasive ventilatory approach, e.g. high flow nasal cannula, could be beneficial to patient before performing intubation in AIIR. (D5) (Anesi, 2020).
If manual bagging is required, gentle ventilation via a supraglottic device instead of bag mask ventilation is recommended. The sufficient seal pressure by this device could minimize aerosol generation throughout the procedure.

1.1. Use disposable airway equipment whenever possible (D5).
1.2. Use a video laryngoscope, to maximize the distance between the operator and the patient's oropharynx. A conventional laryngoscope should be immediately available as well (D5).
1.3. For patients who are mechanically ventilated, pause the ventilator and clamp the endotracheal tube for all circuit disconnections (D5).
1.4. Use a closed suction system as necessary for tracheal suction, and for performing oral suction by Yankauer sucker prior to intubation. It is strongly suggested to prevent dispersion of excessive secretion during the procedure (D5).
1.5. Continuous waveform capnography monitoring device should be used. The correct waveform demonstrates correct placement of endotracheal tube. Personal protective equipment may preclude auscultation to confirm the correct tube placement. Besides, it could give clues for checking the adequacy of the seal when using supraglottic devices (D5).

1.6. Both Rocuronium and Suxamethonium can be used for intubation. Suxamethonium has rapid onset, but shorter duration of action. The longer half-life of Rocuronium may help to prevent coughing or vomiting during the procedure. In case intubation fail, Sugammadex can be used to reverse the neuromuscular blockade of rocuronium (D5).

1.7. The cuff of endotracheal tube should be inflated immediately after intubation to avoid leakage. And the endotracheal tube should be connected to ventilator through a filter and capnography monitoring device. Be sure that the ventilator can only be started after pilot balloon is inflated. Furthermore, the correct position of endotracheal tube is then confirmed by capnography monitoring device. Five-point auscultation could be excluded (D5).
(Cheung et al., 2020) (Wax & Christian, 2020) (Cook et al.,2020)

2. Oxygen Therapy

*High Flow Nasal Cannula Oxygenation (HFNCO)
High Flow Nasal Cannula (HFNC)
*Non-Invasive Ventilation (NIV)
*Intermittent Positive Pressure Ventilation (IPPV)

2.1. HFNC, NIV and IPPV have been used in COVID-19 patients. We recommend to balance the risks and benefits of each device; the infectious risk to healthcare workers; as well as availability of equipment and staff experience, before initiating non-invasive modalities, HFNC or NIV. (D5) (Cheung et al., 2020).

2.2. According to literature, the experiment with a manikin showed that NIV or HFNC would only lead to minimal dispersion of exhaled air when well applied with an optimal fit. (D5) (Hui DS, Chow BK, Lo T, et al., 2019).

2.3. If NIV or HFNC or 6L/min or more of oxygen is considered to be used on suspected or confirmed COVID-19 patient, we recommend he/she should be allocated in an airborne isolation room. (D5) (Cheung, J.C.H. et al., 2020).

2.4. For patient receiving HFNC, we recommend additional placement of a surgical mask on patient when healthcare workers are in the room to prevent the occurrence of spillage. (D5) (Jie et al., 2020).

2.5. For initiation of NIV, it is recommended to choose full-face mask rather than nasal or oronasal mask to minimize dispersion of particle. Besides, the use of helmet could be an option for delivering NIV to patients with COVID-19, which seems better to decrease dispersion. If NIV is used, we prefer to use dual limb circuitry with filter on the expiratory limb on a critical care mechanical ventilator, which may also decrease dispersion compared with the one with single limb circuitry, such as, portable ventilator, V60. (D5) (Cabrini et al., 2020).

2.6. Intubation and mechanical ventilation are recommended to COVID-19 patient with acute respiratory distress syndrome (ARDS). Some indications for intubation include rapid disease progression, lack of improvement while on >40L/min of high flow oxygen and FiO2 (Fraction of Oxygen) > 0.6, evolving hypercapnia, increasing work of breathing, increasing tidal volume, worsening mental status, hemodynamic instability or multiorgan failure. (D5) (Anesi, GL, 2020).

2.7. A recent study showed HFNCO is an effective treatment modality for Covid-19-associated acute respiratory failure, particularly in patients with mild to moderate ARDS and in AIIR, it could be a viable initial alternative to mechanical ventilation. Both HK and overseas institutions use NIV/HFNCO therapy for COVID-19 pneumonia. By using them judiciously, it helps to avoid unnecessary intubation. In some ICUs, HFNCO is also used after extubation to minimize re-intubation and bridging to nasal cannula oxygenation. Infectious risk to staffs is low if applied in airborne isolation facilities and staffs wearing full PPE. Preliminary evidence says HFNC is better than NIV for hypoxemic Covid-19 patients. It could be beneficial to patient before performing intubation in AIIR. (D5) (Anesi, 2020).

3. Ventilation Strategy

Once intubated, we recommend using the lung protective mechanical ventilation strategy. It includes target tidal volume 6ml/kg predicted body weight, plateau pressure ≤ 30 cmH20, target SaO2: 88-95% and pH ≥ 7.25. (D5) (Wax & Christian, 2020). We recommend a peripheral arterial saturation (SpO2) between 90 and 96 percent. (D5) (O'Driscoll et al., 2017).

3.1. Nursing concerns of high-risk

3.1.1. High-risk procedures such as suctioning, change and disconnection of ventilator circuit and use of nebulizer increase the risk of nurses contracting COVID-19 virus because of the possibility of aerosol generation.

3.1.2. We recommend the choice of close in-line system in performing tracheal suctioning as open suctioning method could generate aerosol which would be contagious to healthcare worker. (D5) (Cook et al.,2020).

3.1.3. Change and disconnection of ventilator circuit during use could potentially generate aerosol. Therefore, it is recommended that the above procedure should be performed when the ventilator is adjusted to related maneuvers, e.g. Turn to disconnection/ suction mode (Servo U), to make sure the machine is temporarily not running then resume function after the procedure is finished. (D5) (Cook et al.,2020). Regarding ventilator circuit change for Covid-19 cases, nurses change circuit only when the

circuit is contaminated. When the ventilator fails to function, we change the whole ventilation system i.e. get ready a new Ventilator with preset previous parameter settings and a new circuit, just perform the disconnect and connect action. However, we have different practices in different ICUs and there exists no standardized practice for all ICUs in Hong Kong.

3.1.4. Use of nebulizer and humidified oxygen are avoided to reduce potential viral spread. Inhaled medications should be administered by metered dose inhaler whenever possible. (D5) (Wax & Christian, 2020).

3.2. Use of portable ventilator during patient transfer

Basically, bagging during patient transfer is not suggested as aerosol could be generated if artificial airway system is not intact or dislodged unintentionally. We recommend the use of portable ventilator with expiratory filtering system as an alternative, to ensure close system is achieved in order to minimize aerosol generated. (D5) (Cook et al.,2020).

D. Prone Ventilation

1. Prone Ventilation is a way of delivery of gas for a patient who is in prone position.

This position can improve oxygenation, gas distribution and ventilation perfusion matching by off-loading the internal organ to the lungs. It can be performed either patient is intubated or not but Pelosi et al. (1998) shown this has more significant effect on intubated patient.

2. Prone Ventilation Changes the Physiology of Gas Exchange

Guerin et al. (2013) (B2b) stated that it can improve oxygenation by improving the ventilation perfusion matching via off-loading the heart's weight on the compressed lung tissue, as well as re-distribution of ventilation and perfusion after turning to prone position. For patient with COVID-19 who is intubated but failed oxygenation with low tidal vital volume, prone ventilation can be used according to unit's policy.

3. The Number of Personnel Involved in Turning Position should be minimized in order to balance the staff's exposure to risk of infection.

Extra precaution in prevention of circuit disconnection should be addressed and enhanced by good team approach. Pan et al. (2020) (B2b) recommended all staff should wear full personal protective equipment according to policy of individual organization. The duration of prone ventilation should be at least 12 – 16 hours and can repeat the maneuver daily when sufficient staff are available. Though optimal timing or criteria for discontinuing prone ventilation is unclear, Cornejo et al. (2013) (A1a) studied that can use the criteria similar in patient with ARDS such as PaO2:FiO2 > 150mmhg, FiO2 < 0.6, PEEP < 10 cmH2O.

4. Use of Sedatives and Muscle Relaxants

In order to avoid dys-synchrony during prone ventilation, using sedation and muscle relaxant are the common therapy. However, Watling & Dasta (1994) (B2b) studied the outcomes of using muscle relaxant in patient with ARDS are also conflicting.

5. Caring for a Patient in Prone Position

Patients receiving prone ventilation will be acutely unwell. All safety measures must be considered along with contingency plans for potential deterioration and possible complication such as hemodynamic changes, displacement of the endotracheal tube, a sputum plug, medication lines occluding and in cardiac arrest. Frequent bed safety area checks and patient assessment are recommended:

5.1 Ensure the location of emergency trolley is nearby

5.2 Assess airway patency and check for endotracheal placement and ties

5.3 Check and provide protection for pressure areas on forehead, chins, lips and all bony prominences

5.4 Check for placement of the five-lead cardiac monitor to ensure the cardiac rhythm strip demonstrates correct electrophysiology

5.5 Ensure the probe of the pulse oximeter is attached for the continuous monitoring of patient’s oxygen saturation

5.6 Ensure safe placement and be free from potential occlusion of central venous catheter, arterial catheter, nasogastric tubing, drain a continuous veno-venous hemofiltration (CVVH) catheters

6. Developing Unit Policy

There exists no standard method for moving patient from supine to prone position and vice versa. Davis et al. (2007) (B2a) stated that patient can either be managed as a log roll or staff can use commercial device to facilitate the position turning.). Ball et al. (2001) (B2a) recommended for centers that practice prone ventilation to have either unit policy or procedure guidelines in place to standardize this maneuver.

E. Extra-Corporeal Membrane Oxygenation (ECMO)

1. ECMO Provision for Patients with COVID-19

In mechanically ventilated adults with COVID-19 and refractory respiratory failure despite maximal conventional therapies such as protective lung ventilation, high PEEP, prone positioning, we suggest using ECMO as a rescue strategy for the patients with severe Acute Respiratory Distress Syndrome (ARDS) or refractory cardio-circulatory compromise. For some critically ill patients, referral and transferal to an ECMO center may be required. (D5) (Alhazzani, et al., 2020; Shekar et al., 2020; NHS, 2020; Hospital Authority, 2020; ELSO,2020; EUROELSO,2020; World Health Organization, 2020). There are insufficient data to recommend either for or against the routine use of ECMO for patients with COVID-19 and refractory hypoxemia. (D5) (National Institute of Health, 2020). ECMO provision and patient selection based on health care services capacity, anticipating the possibilities to expand ECMO services in a pandemic by maximizing resources and supply of consumables. (D5) (Shekar et al., 2020; Ramanathan, et al., 2020).

2. Resources and Equipment

2.1. Maintain effective communication and coordination between centers for the allocation of ECMO machines, referral networking and daily monitoring of usage. (D5) (Chief Infection Control Officer (CICO), Hospital Authority, 2020; Shekar et al., 2020; MacLaren, et al., 2020)

2.2. The shelf-life of a primed standby circuit may be extended to 60 days, provided that the circuit is primed with aseptic techniques and normal saline is used as a priming solution. (D5) (Shekar et al., 2020)

3. Preparation and Consent to ECMO Initiation

3.1. While obtaining informed consent to ECMO cannulation, we suggest involving explicitly the decision to discontinue the ECMO therapy if there is an absence of recovery of lungs, heart or both within an acceptable period of treatment

time or if significant complications (e.g. bleeding or thrombosis) developed. (D5) (Shekar et al., 2020)

3.2. Perform ECMO cannulation within Airborne Infection Isolation Room (AIIR) by using bedside ultrasound or trans-thoracic echocardiography. Cannulation team members should put on personal protective equipment (PPE) and strictly adhere to infection control policies for high-risk procedures. (D5) (MacLaren, et al., 2020; Umeda & Sugiki, 2020)

3.3. For ECMO cannulation and related care, standard COVID-19 precautions as recommended by WHO and national health organizations should be used. There are currently no special precautions recommended for blood contact. (D5) (Bartlett, et al., 2020)

3.4. Team briefing before the procedure and a checklist to make sure all necessary equipment has been brought into the AIIR environment. We recommend another dedicated person in full PPE to be ready outside and bring additional supplies if needed. (D5) (MacLaren, et al., 2020)

3.5. Cannulation should be performed by experienced medical officers. A dedicated medical officer should be assigned to maintain patient hemodynamic stability. The patient should be airway protected to avoid unplanned emergency endotracheal intubation during cannulation. (D5) (MacLaren, et al., 2020)

3.6. Recommend the use of large-bore drainage ECMO cannulae to avoid the need for conversion to high flow VV-V ECMO so as to maximize ECMO support. (D5) (MacLaren, et al., 2020)

4. ECMO Retrieval

4.1. ECMO Retrieval should be accomplished by experienced healthcare personnel. We suggest team briefing and coordination among all members before transportation to avoid accidental exposure and contamination. (D5) (Shekar et al., 2020)

4.2. In order to minimize the occurrence of aerosol-generating events, we recommend thorough removal of oral and endotracheal secretion before transportation. Emptying of the gastric content to avoid vomiting during ECMO retrieval. (D5) (Shekar et al., 2020)

4.3. All involved healthcare personnel, supporting staff and drivers are recommended to have full PPE and strictly follow infection control policy throughout the journey. (D5) (Shekar et al., 2020)

4.4. Arrange terminal disinfection for the environment along the path the patient passed by including the corridor, escalator and transport vehicle. (D5) (Shekar et al., 2020)

4.5. We recommend reporting to the Infection Control team if there is any accidental exposure of healthcare personnel for follow up actions. (D5) (Shekar et al., 2020)

5. Specific ECMO Care for a Patient with COVID-19

5.1. Hypercoagulability and cardiovascular complications are associated with poor outcome in COVID-19 patients

5.2. We suggest a higher range of anticoagulation for the patient with COVID-19 (D5) (Shekar et al., 2020)

5.3. Keep the ECMO blood flow rate > 2L per minute to prevent circuit thrombosis (D5) (Shekar et al., 2020)

5.4. If there is no active bleeding, transfusion of blood products and antifibrinolytics are not recommended. (D5) (Shekar et al., 2020)

5.5. The hypercoagulable state of COVID-19 patients may result in circuit thrombosis or membrane oxygenator malfunction, a standby circuit is recommended to be available at all times for emergency oxygenator exchange. (D5) (Shekar et al., 2020)

5.6. The effects of transfusion of convalescent plasma in patients with COVID-19 supported on ECMO is uncertain. (D5) (Shekar et al., 2020)

5.7. Early detection of the abnormal sign of deep venous thrombosis. (D5) (Shekar et al., 2020)

6. Bedside Monitoring

6.1. Bedside patient observation, verifying oxygenator function, circuit checking, prevention of medical device-related pressure injuries and early detection of complications are very important. In addition, we recommend View Camera and Remote Monitoring Devices to enhance patient observation and safety. (D5) (Shekar et al., 2020; MacLaren, et al.,2020)

6.2. Position the ECMO circuit so that it can be viewed and monitored through the glass window of the AIIR room. (D5) (Shekar et al., 2020)

6.3. Cytokine storm is common in critically ill patients with COVID 19 which may be associated with higher risk of delirium. We suggest slightly higher level of sedation to avoid vigorous patient movement and accidental decannulation in isolation room. (D5) (Clark & Vissel, 2020)

6.4. If plasma leak or other damage to oxygenator or circuit is suspected, emergency circuit or oxygenator change should be performed with involved personnel in full PPE. Medical waste disposal and environmental disinfection should be strictly followed in such circumstances. (D5) (Shekar et al., 2020)

6.5. Minimize diagnostic radiology for the patient unless the results may change clinical management or outcome. (D5) (Shekar et al., 2020)

7. Mobilization

Passive and active physiotherapy are suggested to awake ECMO patients so as to improve their pulmonary functional capacity, muscle strength, shorten length of hospitalization, and decrease mortality. (A1a) (Ferreira, et al., 2019)

8. Family Support

Limited visiting time could be arranged for critically ill patients with compassionate reason under the emergency response level restriction. Although the visitors may not be able to come to the bedside, video-conferencing or observing through the glass window may enhance the spiritual connection between patients and relatives. (D5) (Shekar et al., 2020)

F. Cardiopulmonary Resuscitation (CPR) and Special Concerns

Critically ill COVID-19 patients are predisposed to cardiac arrest when encountering hypoxemic respiratory failure secondary to acute respiratory distress syndrome, myocardial injury, ventricular arrhythmias, shock and the use of hydroxychloroquine and azithromycin that can prolong the QT (D5). (Centers for Disease Control and Prevention, 2020). To ensure that patient with COVID-19 who experience cardiac arrest get the best possible chance of survival without compromising the safety of rescuers, it is recommended to modify the resuscitation processes and practices of COVID-19 patients (D5). (Edelson, et al., 2020).

1. Reduction of Provider Exposure to COVID-19 During CPR

Resuscitation added risk to healthcare workers. Firstly, the implementation of CPR involves performing numerous aerosol-generating procedures, including chest compressions, positive-pressure ventilation, suction and establishment of advanced airway. Aerosolized viral particles can remain suspended in the air with a half-life of 1 hour and be inhaled by any personnel nearby (C4) (Van Doremalen, 2020). Second, resuscitation require numerous healthcare workers to work in close proximity to one and other and the patient. Third, these high-stress emergency events may result in lapses of infection control practices. Therefore, it is essential to protect healthcare workers from unnecessary exposure. Measures that reduce provider exposure to COVID-19 during CPR are suggested in the following.

1.1. All rescuers should don PPE to guard against contact with both airborne and droplet particles before entering the CPR scene. (D5). (Edelson, et al., 2020).

1.2. Personnel in the room should only be limited to only those essential for patient care. (D5). (Edelson, et al., 2020).

1.3. To reduce the number of rescuers, it is recommended to use automated mechanical chest compression device e.g. LUCAS in chest compression. (D5). (Edelson, et al., 2020).

1.4. Clearly communicate the infection risk of COVID-19 patients to any new providers before their arrival on the scene.

2. Prioritization of Oxygenation and Ventilation strategies with Lower Aerosolization Risk

Considering the unique pathophysiology of COVID-19, the reversal of hypoxemia is a central goal of resuscitation. (D5). (Edelson, et al., 2020). Intubation carries high risk of aerosolization. However, if the patient is intubated with a cuffed device and connected to a ventilator with closed circuit and HEPA filter, the risk of aerosolization is reduced when compare with other forms of positive-pressure ventilation.

2.1. Attached HEPA filter securely to all exhalation ports of manual or mechanical devices before administering any breaths. (D5). (Edelson, et al., 2020).

2.2. After assess the rhythm and defibrillate if necessary, patient encountered cardiac arrest should be intubated with a cuffed device at the earliest feasible opportunity and connected to a ventilator with HEPA filter. (D5). (Edelson, et al., 2020).

2.3. Assigning the most skilled provider with the best chance of first-pass to intubate. (D5). (Edelson, et al., 2020; Christian & Wax, 2020).

2.4. Minimize the chance of failed intubation by pausing chest compressions during intubation. (D5). (Edelson, et al., 2020).

2.5. It is recommended to use video laryngoscope to perform intubation in order to reduce intubator’s chance of exposure to aerosolized particles. (D5). (Edelson, et al., 2020).

2.6. During preoxygenation before intubation, it is crucial to use a bag-mask device with HEPA filter connected. It is recommended to use “two-hands bag-mask ventilation techniques" to ensure the bag mask device is tightly sealed. (D5). (Edelson, et al., 2020).

2.7. For patient with spontaneous breathing, passive oxygenation with non-rebreathing face mask covered by a surgical mask can reduce the risk of viral aerosolization. (D5). (Edelson, et al., 2020).

2.8. If intubation is delayed, consider manual ventilation with supraglottic airway with a HEPA filter. (D5). (Edelson, et al., 2020) ".

2.9. Once on a closed circuit, disconnections should be minimized to reduce aerosolization. (D5). (Edelson, et al., 2020).

2.10. For ventilator settings, change mode to pressure control ventilation and limit pressure as needed to generate adequate chest rise (targeted at 6ml/Kg in ideal body weight). Adjust respiratory rate to 10/min and trigger to OFF to prevent auto-triggering with chest compression. Optimize positive end-expiratory pressure to balance lung volumes and venous return. (D5). (Edelson, et al., 2020).

2.11. Monitor signs and symptoms of deterioration and minimize the need for emergent intubations that put patients and health care workers at higher risk. (D5). (Edelson, et al., 2020).

3. Appropriateness of Starting and Continuing Resuscitation

The mortality of critically ill patient with COVID-19 is high and increase with age and comorbidities, particularly cardiovascular disease (D5). (Centers for Disease Control and Prevention, 2020). It is reasonable to consider these factors and severity of illness in determining the appropriateness of resuscitation. It is important to strike a balance between the chance of success and the risk to rescuers, as well as other patients whom limited resources are being diverted.

3.1. Advanced care directives and goals of care should be set and in place with COVID-19 patients and relatives in anticipation of the need of increased level of care. (D5). (Edelson, et al., 2020; National Institute for Health and Care Excellence, 2020).

3.2. Institutional policy should be available to guide frontline health care workers in determining the appropriateness of starting and terminating CPR for COVID-19 patients, with consideration of patient risk factors and chance of survival. (D5). (Edelson, et al., 2020).

4. Resuscitation of COVID-19 Patient in Prone Position

4.1. For suspected or confirmed COVID-19 patients in prone position without advanced airway, placed patients in supine position for resuscitation. (D5). (Edelson, et al., 2020).

4.2. The effectiveness of CPR in prone position is not completely known. For patient in prone position with advanced airway, avoid turning the patient to supine position unless able to do so without risk of equipment disconnections and aerosolization. (D5). (Edelson, et al., 2020).

4.3. Successful defibrillation can be achieved with pads either applied in anterior-posterior position. (C4). (Mazer, et al., 2003); posterior-lateral or in the bi-axillary positions. (D5). (The Intensive Care Society, 2019).

4.4. To provide CPR with patient remaining prone, it is recommended to use "two-handed technique" for chest compressions over the mid-thoracic spine located between the two scapula. (D5). (Resuscitation Council UK, 2015). However, this technique is not practiced in Hong Kong ICUs.

5. Maternal Cardiac Arrest

5.1. Pregnant women with COVID-19 may have increased risk of acute decompensation because of cardiopulmonary physiological changes (D5). (Edelson, et al., 2020).

5.2. Preparation for perimortem delivery after 4 minutes of resuscitation should be initiated early in resuscitation algorithm to allow the assembly of obstetrical and neonatal teams with PPE even if ROSC is achieved and perimortem delivery is unnecessary. (D5). (Edelson, et al., 2020).

G. High Risk Procedures – Aerosol Generating Procedures

1. Aerosol-generating Procedures

Aerosol-generating procedures with documented increase in risk of respiratory infection transmission in ICU are bronchoscopy; open suctioning of respiratory tract (including tracheostomy care); non-invasive positive pressure ventilation (NIPP-BiPAP & CPAP).

1.1 Endotracheal intubation that required healthcare workers to be in close proximity to patient's airway for a prolonged period of time would increase the risk of disease transmission. (C4). (Tran, et. al, 2020).

1.2. Chest compression can produce excretions from patient's nose and mouth during CPR. (D5). (Resuscitation Council UK, 2020).

1.3. Bronchoscopy and open suctioning of respiratory tract are procedures that stimulate coughing and promote generation of aerosols

1.4. High incident of CPAP/BiPAP mask leak increase risk of viral aerosolization and spread. (D5). (Christian & Wax, 2020).

1.5. CPAP/BiPAP should be avoided in COVID-19 patients as it may increase the risk of delayed deterioration, leading to need for emergency intubation that put patients and health care workers in higher risk. (D5). (Christian & Wax, 2020).

2. Risk of Infection Induced by Aerosol-generating Procedures

Aerosol-generating procedures with controversial/ limited studies evaluating the risk of respiratory infection transmission are high-frequency oscillatory ventilation, nebulizer therapy and sputum induction.

High frequency oscillatory ventilation (HFOV) is an alternative of lung protective mechanical ventilation strategy but rarely used in adult patients in Hong Kong.

Nebulization of medications should be avoided as it may increase the risk of viral aerosolization and spread. Bronchodilators should be administered by meter-dose inhalers. (D5). (Christian & Wax, 2020).

3. Nasopharyngeal Aspiration (NPA) and High Flow Oxygen

These procedures are theoretically at risk of dispersal of infectious respiratory droplets, therefore they should be performed in conditions as required for aerosol-generating procedures in high-risk patient areas. (D5). (CHP, 2016).

High flow oxygen via nasal cannula may cause increased risk of viral spread through aerosol generation. The use of high flow nasal cannula should be limited to patients in appropriate airborne isolation (D5). (Christian & Wax, 2020).

4. Humidified Oxygen Should Be Avoided to reduce potential viral spread unless with appropriate airborne isolation. (D5). (Christian & Wax, 2020).

H. Early Mobilization

1. Facts about Early Mobilization

1.1 In the context of acute COVID-19 infection, mobilization is encouraged early in the course of illness when safe to do so. (B3a) (World Health Organization, 2020).

1.2 Early mobilization is suggested to reduce the risk of developing ICU delirium and ICU acquired weakness. (B3b) (Kotfis, Roberson & Wilson, 2020).

1.3 The safety, feasibility, and effectiveness of early mobilization have been extensively reported. (B2b) (Maheswaran, Fromowitz & Goldfarb, 2020).

1.4 Early mobilization is suggested for critically ill patient with continuous therapies and different life saving devices in place. (B2c) (Liu, Ogura & Takahashi, 2018).

1.5. Progressive early mobilization is suggested to be started upon hemodynamic and respiratory stabilization, typically within 24–48 hours of ICU admission. (B2a) (Adler & Malone, 2012).

2. Early Mobilization Protocol

2.1 Early mobilization is an evidence-based practice and should be incorporated into daily practice. (B2a) (Cameron, Ball & Cepinskas, 2015).

2.2 Having an early mobilization protocol is recommended. (B2a) (Cameron, Ball & Cepinskas, 2015).

2.3 An early mobilization protocol is supposed to be one with multidisciplinary approach involving physicians, nurses, and allied health professionals to maximize patient outcome. (B2c) (Green, Marzano & Leditschke, 2016).

2.4 Mobilization should be categorized into different levels of activities. Activities should include passive or active resisted joint range of motion exercises, passive tilting in bed, bed mobility, bed cycling, sitting out of bed, sitting to standing, then walking. (B2c) (Liu, Ogura & Takahashi, 2018).

2.5 The details of early mobilization protocol vary. It should include:

2.5.1 Safety screening of respiratory, circulatory and neurological condition. (B2c) (Liu, Ogura & Takahashi, 2018).

2.5.2 Assessment of patient sedation level by Richmond Agitation-Sedation Scale. (B2c) (Liu, Ogura & Takahashi, 2018).

2.5.3 Levels of mobilization to be determined by sedation level assessed. (B2c) (Mayer, Hornsby & Soriano, 2020).

2.5.4 Scheduled daily activities and frequency of mobilization. (B2c) (Mayer, Hornsby & Soriano, 2020).

2.5.5 Record of signs of intolerance and related interventions. (B2c) (Mayer, Hornsby & Soriano, 2020).

3. Special Recommendations

3.1 Assess and identify minimum number of staff required to safely mobilize patients. (B3a) (Thomas, Baldwin & Bissett, 2020).

3.2 Any mobilization that may result in coughing and expectoration of mucus is suggested to be aerosol generating procedure. (B3a) (Thomas, Baldwin & Bissett, 2020).

3.3 Droplet and airborne precautions are recommended. Use appropriate PPE properly according to the latest infection control guidelines. (B3a) (Thomas, Baldwin & Bissett, 2020).

3.4 Provide surgical mask to patient without advanced airway to put on before mobilization. (B3a) (Thomas, Baldwin & Bissett, 2020).

3.5 Secure artificial airway properly and designate an airway person to prevent any inadvertent disconnection of ventilator connections or tubing(s). (B3a) (Thomas, Baldwin & Bissett, 2020).

3.6 Perform mobilization activities in the single negative pressure room. (B3a) (Australian and New Zealand Intensive Care Society, 2020).

3.7 Avoid sharing of equipment between patients. Clean and disinfect the used mobility aids such as walking frame, chairs and in-bed cycling ergometer if sharing is unavoidable. (B3a) (World Health Organization, 2020).

I. Psychological Care of Isolated Patients with Covid-19 and Their Families

1. Psychological Needs of Isolated Covid-19 Patients and their Families

1.1 Identify patient at risk, e.g. history of psychological disorders. Patient with history of psychological disorders is associated with psychological distress after experiencing any disease-related trauma. (C4) (Alvarez & Hunt, 2005).

1.2 Patients with COVID-19 experience loneliness, anger, anxiety, depression, insomnia and post-traumatic stress symptoms (B2a) (Xiang, et al., 2020).

1.3 Perceived danger, uncertainty, physical discomfort, medication effect, fear of virus transmission to others, and overwhelming negative news from mass media are the contributing factors of mental disruptions of the patients, which could negatively affect their social, occupational functioning and quality of life. (C4) (Morson, Caron, McCloskey, & Brunet, 2017).

1.4 Prevalence of posttraumatic stress symptoms in COVID-19 survivors was 96.2% (95%CI: 94.8%-97.6%) in a study of China. (A1a) (Bo, et al., 2020).

2. Support Interventions

ICU nurses need to engage in patients' psychological support in a systematic way, and they need to acknowledge the high priority of support interventions. Such support will need to be prescribed, planned, documented and along with patients' responses. (B2a) (Papathanassoglou, 2010)

2.1 Orientate the environment of isolation unit and related treatment to patient. (B2a) (World Health Organization, 2020).

2.2 Explore the psychological needs from patient proactively. (B2a) (World Health Organization. 2020).

2.3 Provide adequate information about patient's situation with effective and rapid communication. (B2a) (Brooks, et al., 2020).

2.4 Help patient to express feelings such as fear and sadness. (B2a) (World Health Organization. 2020).

2.5 Collaborate with physician and refer patient to psychological service as indicated. (B2a) (World Health Organization. 2020).

2.6 Manage mental health condition, including acute delirium and depression accordingly. (B2a) (World Health Organization. 2020).

3. Family Centered Care – proactive condition update by staff

3.1 Provide simple and clear information and repeat as indicated. (B2a) (World Health Organization.2020).

3.2 Provide clear and concise communication in a respectful way. (B2a) (Brooks, et al., 2020), (World Health Organization. 2020).

3.3 Engage family members for supportive networks by providing valid information. (B2a) (World Health Organization. 2020).

3.4 Provide information to family members to execute preventive measures. (B2a) (World Health Organization. 2020).

3.5 Educate family members to be on the alert for abnormal signs and symptoms and seek medical advice if necessary. (C4) (World Health Organization. 2020).

3.6 Empower family members to follow public health measures, such as quarantines and isolation to safeguard personal and public health. (C4) (Brooks, et al., 2020).

4. Innovative Communication Methods during Isolation Period

4.1. Facilitate patient for social contacts and connection, not limited to phone call and video call. (C4) (World Health Organization. 2020).

4.2. Provide unrestricted access to Internet and online social connection as far as possible if patient's condition tolerated, limited access to Internet and information posed increased stress to patients with COVID-19. (C4) (Xiang, et al., 2020).

4.3 ICU nurses may better psychologically support the family members of critically ill patients through information provision and education with the interactive mobile technology (such as Tablet device). Use of such technology also enhanced satisfaction of information/education need of the family members. (C4) (Chiang, et.al., 2017).

5. End-of-life Issues

5.1 The epidemiological information regarding SARS-CoV-2 is evolving, making the prognostication could be a challenge, causing considerable distress among patients and caregivers. (C4) (International Association for Hospice and Palliative Care, 2020).

5.2 Shared decision-making among healthcare team, patients, and caregivers is the core process in planning the end of life care for patient. (B2a) (Arya, Buchman, Gagnon, & Downar, 2020)

5.3 Having the advanced care plans updated for patients with frailty or comorbid illness. (C4) (International Association for Hospice and Palliative Care, 2020).

5.4 Focus on compassionate care and dignity and mitigate social isolation at the end of life and caregiver distress. (C4) (International Association for Hospice and Palliative Care, 2020).

5.5 Discuss with patients and caregivers about the use of opioid medicines to patients to better alleviate patient suffering in life and death. (C4) (Lukas, Felicia, Liliana, Cornelis, & Afsan, 2020)

5.6 Gain access to essential palliative care at the end-of-life including bereavement support could be limited due to isolation. (C4) (Costantini, Sleeman, Peruselli, & Higginson, 2020).

5.7 Basic palliative care training to all medical and nursing has been recommended. Now is the time to insist on rapid capacity-building for clinicians in symptom control and management of end-of-life conversations. Online training is available to help prepare medical personnel to provide some palliative care at all levels of care. (B2a) (Lukas, Felicia, Liliana, Cornelis, & Afsan, 2020).

5.8 Alleviate the effect of separation in end-of-life situations by all possible measures. (B2a) (International Association for Hospice and Palliative Care, 2020).

5.9 Enable video calling to connect patients and family members who are separated due to travel and visitor restrictions. (C4) (International Association for Hospice and Palliative Care, 2020).

5.10 Provide holistic support to patients and caregivers including emotional, psychological, social, and spiritual needs by engaging interprofessional palliative care team. (C4) (International Association for Hospice and Palliative Care, 2020).

5.11 Judicious allowance of family visitation to dying patients should be reviewed case by case. Visitation was limited to immediate family for all ICU patients during the pandemic. All visitors to ICU are screened for potential COVID-19 infection, for example, travelling history, temperature and respiratory symptoms screening. Maintain a visitor log for contact tracing and activity mapping of confirmed cases. (C4) (Australian and New Zealand Intensive Care Society, 2020).

5.12 Long-term preparedness strategies that embed palliative care into the core of medicine. Expand all medical, nursing, social work, and community health worker curricula, as well as training of clergy, to include core palliative care competencies. Establish standard and resource-stratified palliative care guidelines and protocols for different stages of a pandemic and based on rapidly evolving situations and scenarios. (C4) (Lukas, Felicia, Liliana, Cornelis, & Afsan, 2020).

ICU Professionals should employ the palliative approach in delivering end-of-life care. The focus should be multi-dimensional (Physical, emotional, social and spiritual) and should aim at improving quality of life. The care should be patient and family-centered; involve patient and family in the development of care goals and all other care processes as well as decision making; and integrate with disease modifying therapies. Basically, the essential care elements for end-of-life patients are: staff be prepared to care and be responsive to patients' concerns; care be patient centered and individualized; patient's personhood and dignity preserved; continuity of care and comfort sustained; goals of care be jointly decided with patients and their families; symptoms control optimized; psycho-spiritual care delivered; social supports enhanced; the coordinated care is offered by a team.

Hence, capacity building for all ICU clinicians and the training of core skills on palliative care approach to provide the care at all levels is of utmost importance. Moreover, visitation restriction aimed to protect the public must be weighed against the COVID-19 patient's & family's suffering. ICU team is encouraged to engage specialist palliative care providers when encountering patients at end of life with numerous and complex needs.

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IV Nursing Management

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Authors and co-authors:	**Chapter**
T.N.Y. FUNG, MNurs; RN; FHKAN (CC); FHKAN (C) & W.S. LO, MSc. (ACP in CC); RN	I&II
D.WK. TONG, Ph.D.; MNurs.; RN; FHKAN (M)	III
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