Perspectives

Intensive Care Unit Management of the COVID-19

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Abstract

Coronavirus disease of 2019 is the public health emergency of international concern (PHEIC). COVID-19 leads to the development of acute respiratory distress syndrome (ARDS) in some patients. The management of acute respiratory distress syndrome in such patients involves non-invasive and invasive ventilation techniques. The non-invasive ventilation techniques must be employed first before initiating invasive mechanical ventilation techniques. High Flow Nasal cannula, Bi-level Positive Air Pressure (BiPAP) and Helmet ventilation are the non-invasive techniques that are employed in the management of COVID -19 related acute respiratory syndrome. The hazard of aerosol transmission of the virus to the Healthcare and paramedical staff must be taken into consideration before using any of these non-invasive techniques. The burden on hospital ventilatory equipment can also be appeased when non-invasive techniques are utilized. Early intubation of the patient must be avoided if possible. The clinical presentation of the patient and the vital signs like oxygen saturation and respiratory rate must be monitored regularly in order to assess the need of the patient to be ventilated. The careful use of non-invasive and invasive ventilation techniques can reduce the mortality from acute respiratory distress syndrome in COVID-19 patients.

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Introduction

COVID-19 has emerged as a new disease caused by the SARS-CoV-2 virus. It is a novel corona virus. The cases of this disease first emerged in the city of Wuhan, China during the end of 2019. The disease soon spread around the globe and was declared a pandemic by WHO on March 11, 2020[1]. The most common symptoms of the disease are fever, dry cough, fatigue and dyspnea[2]. Uncommon symptoms include sore throat, diarrhea, conjunct-tivitis, headache, loss of taste and smell. The disease spreads from the infected person’s oral and nasal pathways via small aerosol particles when the affected person coughs, sneezes, talks or breathes heavily, particularly crowded indoor spaces[3]. Social distancing, regular hand-washing and usage of face masks are the most common measures being taken to contain the spread of the disease. Two main diagnostic tests for confirmation of COVID-19 are real time PCR (sample taken by nasal swab) and serology testing for COVID-19 antibody. Chest X-ray would generally reveal bilateral increased interstitial markings. On Computerized tomography, ground glass opacity is the most common radiological finding[4,5]. Lymphocytopenia is present in most patients[6]. Older patients usually with comorbidities including diabetes and hypertension are more likely to get critically ill[7]. Acute hypoxemic respiratory failure from acute respiratory distress syndrome (ARDS) is the most common complication in patients of COVID-19 admitted to the ICU, followed by sepsis, shock, myocardial dysfunction, and acute kidney injury[8,9]. ICU management of COVID-19 patients is performed using different techniques like CPAP, BIPAP, Helmet ventilation, invasive mechanical ventilation and in selected cases ECMO.

Discussion:

Course of Disease:

The course of COVID-19 can be divided into 3 stages.

Stage 1: Early Infectious phase: It is marked by mild constitutional symptoms of fever > 99.6ºF, dry cough, diarrhea and headache. Clinical signs of stage 1 include Lymphopenia, increased prothrombin time, increased D-Dimer and LDH (mild).

Stage 2: Pulmonary Phase: It is marked by clinical symptoms of shortness of breath and hypoxia (PaO_2 / $FiO_2 \leq$ 200mgHg). Clinical signs of abnormal chest imaging, transaminitis and normal-high procalcitonin.

Stage 3: Hyper-inflammatory Phase: It is the host inflammatory response phase marked by ARDS, SIRS/Shock and Cardiac failure. Clinical signs include elevated inflammatory markers (CRP, LDH, IL-6, D-dimer, Ferritin), Troponin & NT-proBNP elevation.[10,11,12]

Potential therapies for treatment of the disease include Remdesivir, Steroids, convalescent plasma transfusion[13]. Efforts should be made to reduce immune-suppression during the early stages of the disease. Human immunoglobulins, IL-6 inhibitors, IL-2 Inhibitors and JAK Inhibitors are potential therapies for late stage of the disease[14,15].

C-ARDS

COVID-ARDS(C-ARDS) stands for COVID-19 associated acute respiratory distress syndrome. With time progression in this pandemic, the doctors handling COVID-19 cases worldwide have put forward a new observation about the uniqueness of ARDS related to COVID-19. ARDS is defined as respiratory failure occurring within a week of known clinical insult with bilateral opacities on chest imaging and decreased lung compliance. Management usually includes mechanical ventilation with higher PEEP adjustment. The notion that C-ARDS is different is still debatable.

COVID-19 involves vascular injury[16] resulting in destruction of capillary epithelial interface by directly injuring epithelium and indirectly endothelium by the stimulated immune system. This is also supported by the data which shows patients, who are at high risk of vascular diseases e.g. diabetics, hypertensives, hyperlipidemias have higher risk of getting COVID rel-ated severe disease. ARDS patients have severe hypoxemia and have reduced lung compliance which is managed by mechanical ventilation and adjusting PEEP to prevent lung collapse. COVID-19 patients are also hypoxemic in initial stages but with more compliant lungs than in non COVID-19 ARDS. [17] COVID-19 associated ARDS can present with reduced lung recruitability and compliance seen in some patients.[18] This is important in the decision of mechanical ventilation as scarcity of resources in this ongoing pandemic especially in developing countries. Two phenotypes of CARDS have been observed which are denoted by L and H for low and high respecttively[19]. Low means lungs with low recruitability, elastance and lung weight while high phenoltype corresponds to high elastance, lung weight and recruitability, so as a result high type requires early intubation and mechanical ventilation assistance more than the low one. Patients who usually present with low phenotype may or may not progress compared to high phenotype. But this classification still requires further evidence.

Escalation of Oxygen Therapy Algorithm in COVID-19:

Escalation of Oxygen Therapy algorithm in COVID-19 involves the goal oxygen saturation of 92-96 %. Options are Low Flow Nasal Cannula (LFNC) 1-6 L followed by HHHFNC (2 hours trial). Escalate to Helmet Ventilation if oxygen saturation is persistently < 92%, RR < 30, pH > 7.2, mild respiretory distress, and good Mental Status /airway protection. If it fails then, Mechanical Ventilation is recommended. Escalate directly to Mechanical ventilation if persistent SaO2 < 92, RR > 30, pH < 7.2, poor Mental Status /airway protection, intolerance, emesis and copious secretion are seen[20].

Awake Proning:

Decreased oxygen saturation is a common presentation in COVID-19 patients. Proning has been a useful technique in the management of COVID-19 ICU patients.[21,22] It has shown to be beneficial in improving oxygenation and V/Q mismatch in ventilated patients with ARDS. It also reduces the risk of ventilation induced lung injury[23]. Awake proning improves oxygenation by aerating the non-aerated dorsal lung territories, Improved CO_2 clearance is also reported. Early application of awake prone position in patients with HNFC has been shown to avoid intubation [24].

HHHFNC

HHHFNC stands for heated humidified high flow nasal cannula. It is widely acceptable among COVID-19 guidelines for patients with low blood oxygen saturation and ARDS except when early intubation is recommended.

Benefits of HHHFNC include improved oxygenation, high flow rates (40-60 L/min), generation of positive nasopharyngeal/ tracheal airway pressure, decreased anatomic dead space secondary to washout of upper airways, decreased metabolic cost of breathing / reduced carbon dioxide generation, improved work of breathing, the inspired gas is preconditioned (heated and humidified), better secretion clearance, superior comfort (mobilization, talking, eating/drinking, anxiety)[25].

It is desirable to target the highest flow tolerated by the patient to reduce work of breathing while separately titrating FiO_2 to achieve the desired SpO_2. Adjust the temperature to match that of patient.

Transmission of COVID-19 to hospital staff has been a serious issue in the management of critical patients. Aerosol transmission in HHHNFC during coughing and sneezing appears to be minimal assumed the patient wears mask and there is negative pressure in the room.

Helmet Ventilation

Helmet ventilation is a non-invasive ventilation method. It consists of a transparent helmet covering head and face with a Soft Collar in the neck region. Most often it is used with a ventilator, can be used with V-60 BIPAP machine as well. Due to its non-invasive nature, it is comfortable and is better tolerated by the patients with less associated complications. Moreover, they can enjoy mobility and there is less need of sedatives and reduction in need for invasive mechanical ventilation. Helmet is connected to a ventilator / Bipap and oxygen flowmeter is opened, PEEP is adjusted initially to 5cmH_2O and FiO_2 (fraction of inspired oxygen) to 60%. On reassessment at specific intervals generally 15-30 minutes, if work of breathing and PO_2 does not improve, increase the PEEP to 10cm H_2O and titrate oxygen to keep saturation above 92 %. If work of breathing increases and/or oxygen saturation does not improve then proceed to invasive mechanical ventilation.

According to JAMA STUDY titles “Effect of non-invasive ventilation delivered by helmet vs face mask on the rate of endotracheal intubation in patients with ARDS” there is a striking reduction in endotracheal tube intubation in patients with helmet ventilator as compared to oxygen face mask.
It also stated that use of helmet ventilation reduces the need of endotracheal intubation to about 20-30% and results in reduced mortality which is almost 80% in intubated patients of COVID-19.

BSLMC Refractory Hypoxemia Protocol:

According to the Berlin definition for acute respiratory distress syndrome and management survey, the onset of acute respiratory distress syndrome could be within one week of insult (usually 72 hours). Hydrostatic edema should not be the primary causation of acute respiratory distress syndrome, imaging must show bilateral opacities on chest X-Ray. Acute respiratory distress syndrome is further characterized into three classes, mild acute respiratory syndrome, moderate ARDS and severe ARDS based on PaO_2 / FiO_2 ratio. It is the ratio of arterial oxygen partial pressure (PaO_2 in mmHg) to fractional inspired oxygen (FiO_2 expressed as a fraction).

Mild ARDS has PaO2/FiO2 values from 200-300 mmHg with PEEP $\geq$ 5cm H_2O. The mortality associated with mild ARDS is 27%.

Moderate ARDS, the PaO_2/FiO_2 range from 100-200 mmHg with PEEP $\geq$ 5cm H_2O. The mortality associated with moderate ARDS is 32%.

Severe ARDS, the PaO_2/FiO_2 range from $\leq$ 100mm Hg with PEEP $\geq$ 5 cmH_2O. The mortality associated with moderate ARDS is 45%.

The target tidal volume is 6cc/kg predicted body weight (PW) and Pplats $\leq$ 30 cm H_2O. Consider higher PEEP in moderate and severe ARDS and keep PaO_2 55-80 mmHg or SpO_2 88-95% with pH $\leq$ 7.25. If the P: F is $\leq$150 mmHg then sedate and consider early proning. Consider neuromuscular paralysis and perform lung recruitment maneuvers. If the P: F $\leq$ 80 mmHg then consider alternative therapies such as ECMO.

ECMO Criteria

Patient fulfilling the following criteria should be considered for ECMO (if available):

Acute Respiratory failure, age < 60, meets hypoxemia criteria (EOLIA criteria), duration of mechanical ventilation less than 7 days, single organ failure, no contraindications for ECMO, RESP SCORE of -1 to -2 with expected survival of 57% and risk class III.

Contraindications to ECMO include : Advanced age, clinical fragility scale category $\geq$ 3, mechanical ventilation > 7 days, significant underlying comorbidities: CKD $\geq$ III, Cirrhosis, dementia, baseline neurological disease which would preclude rehabilitation potential, disseminated malignancy, advanced lung disease, uncontrolled diabetes with chronic end organ dysfunction, severe deconditioning, protein energy malnutrition, severe peripheral vascular disease, other preexisting life-limiting medical condition, non -ambulatory or unable to perform activities, severe multiple organ failure, severe acute neurologic injury (e.g., anoxia, stroke), uncontrolled bleeding, contraindications to anticoagulation, inability to accept blood products or ongoing CPR.

ECMO:

ECMO stands for extracorporeal membrane oxygennation. Extracorporeal means outside the body. It is a life-support machine that oxygenates the blood and remove carbon dioxide outside the body. The ECMO machine is similar to the heart-lung by-pass device used in open-heart surgery. It acts as an artificial lung. It pumps and oxygenates a patient's blood outside the body, allowing the heart and lungs to rest. Extracorporeal membrane oxygenation is an indication when the patient is in severe respiratory distress as occurs in critically ill COVID-19 patients. The inability of the critically covid-19 patients to oxygenate their blood can be life-threatening. The patient can be placed on ECMO so that the oxygenation and stable hemodynamics are ensured. The use of ECMO for circulatory support was independently associated with higher in-hospital mortality. So, the effectiveness of ECMO in decreasing the in-hospital mortality is still debatable.

ECMO Complications

Extracorporeal membrane oxygenation is achieved via a complicated machine oxygenating and maintaining flow of blood in critically ill patients of Covid-19. ECMO is not without its own complications, which actually depend on severity of patient's underlying critical condition and duration of this treatment. Most of the initial complications are cannulation related e.g. hemorrhages. Then later are renal complications, patients usually develop acute kidney injury which is vascular in origin. Deranged coagulation profile is often seen with IV thrombosis. Infectious diseases, usually machine related infections and others like bacterial pneumonia, aspiration pneumonia, etc. Neurological complications including delirium, cerebrovascular injuries are also reported. Cardiovascular complications as well as thrombotic complications, as COVID-19 is already known for pro coagulative effects, other vascular malformations specially after removal from ECMO support like aneurysms, AV fistulas are also seen.

Miscellaneous innovations and Lessons Learnt

1. Nebulization should be avoided due to virus aerosolization.
2. Automated CPR use for cardiac arrests should be encouraged to minimize exposure.
3. Access to proper and responsible use of PPEs and face shields
4. Self-care should be a priority of healthcare providers
5. Healthcare providers i.e. doctors and nurses should be maximally facilitated to reduce both emotional and physical burnout rate as high burnout increases inefficiency of the system.
6. Use of intubation and extubation devices to minimize exposure
7. Designated intubation and procedure teams
8. Moving IV pumps, CRRT machine and ventilator controls outside the room to minimize exposure to healthcare workers
9. Proning aid devices

Conclusion:

Many methods are being used to save lives of critically ill COVID-19 patients in ICU. Efforts are being made to manage the patients with ARDS initially with low flow and then escalated to high flow, Non-invasive modalities and finally invasive mechanical ve-ntilation. Proning especially awake proning and early neuromuscular paralysis is helpful. If available EC-MO can be a bridge to recovery or lung transplant with reasonable survival.

Conflict of Interest:

There was no conflict of interest among the authors.

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