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COVID 19 ARDS: Mechanical Ventilation

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ABSTRACT

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Consider attention has been focused to spread awareness about COVID 19 and its associated complications among medical professionals. Here we attempt to elucidate the ventilator management of COVID 19 patients with severe hypoxemia.

Keywords: COVID 19, Acute respiratory distress syndrome, Lung protective ventilation, Compliance

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INTRODUCTION

Today, World is facing a global health crisis due to COVID-19 pandemic. In the last 20 years Corona virus has attacked the human race thrice with devastating consequences. For the first time, a corona virus infection has been declared a pandemic by WHO on March 2020.The renowned journal "Science" has stated that substantial undocumented infections facilitate the rapid dissemination of novel Corona virus.[1] This aspect of COVID-19 explains the rapid geographic spread of SARS CoV 2 and points to the fact that containment of this virus will be particularly challenging.[2] We have adopted various measures like lockdown, social distancing and quarantine to combat the surge in spread, improving healthcare facilities and enhancing our knowledge to battle the virus is our strategy. Here we attempt to brief you on the basics of ventilation in COVID 19 ARDS.

From Chinese data if 100 people are contracting this disease 19 will have a severe disease and 5 will require an ICU stay and mechanical ventilation. The main indication for ventilator support includes Acute Respiratory Distress Syndrome, hemodynamic instability and sometimes severe pneumonia.[3]

Clinical syndromes associated with covid-19 includes

- Mild illness
- Pneumonia
- Severe pneumonia
- Acute respiratory distress syndrome(ARDS)
- Sepsis
- Septic shock

WHO defines hypoxemia as saturation below 90%. The Surviving sepsis campaign for COVID 19 recommends oxygen therapy when the saturation is less than 90%.It also recommended that '*mechanical ventilated patients with COVID-19 should be managed similarly as any other case of acute respiratory failure in the ICU*'. But an article published by Gattinoni et al in intensive care medicine journal explains how this disease is in many ways different from conventional ARDS.[4]

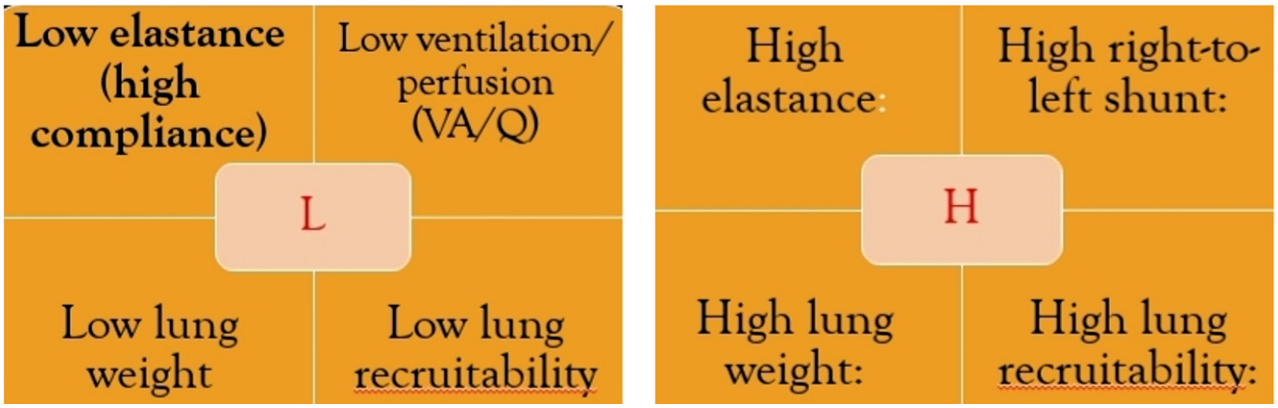

Figure 1. **Phenotype L and H Characteristics**

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Covid ARDS vs classical ARDS

Only 20-30% of patients presenting with severe hypoxemia fulfils all the criteria of conventional ARDS according to the Berlin's criteria. This is newly defined as the 'H' phenotype **(Figure 1)**.

Rest of the patients has a combination of severe hypoxemia and highly compliant lung known as the 'L' phenotype. The exact mechanism of hypoxemia in the L phenotype is not clear. It is mainly attributed to the pulmonary vascular dysregulation and pulmonary microthrombosis. L phenotype can lead to increased work of breathing, patient self inflicted lung injury (P-SILI) and lung edema. The L phenotype can progress into the H type if not managed appropriately.[5]

If work of breathing is normal the L phenotype (majority of patients) can be managed conservatively with O2 therapy and Non-invasive techniques. Invasive ventilation is to be preferred early if the L phenotype presents with increased work of breathing.[6] Increased work of breathing is indicated by large swings in CVP, large negative pleural pressure as measured with oesophgeal manometer and in patients on NIV with tidal volume more than 9-9.5ml/kg.

Non-invasive techniques

High flow nasal cannula is preferred non-invasive technique compared to non-invasive ventilation owing to its less chance of aerosol generation as well as the chance of application of a surgical mask over the device while in use.[7]

If Non-invasive ventilation is to be used it should be initiated in an isolated room ideally with an ICU ventilator with dual limb circuit and two viral filters. Patients on NIV needs to be frequently reassessed and if worsening at any point has to be considered for invasive ventilation.[8] A worsening PaO_2/FiO_2 ratio less than 150 and increasing work of breathing with non-invasive techniques can be taken as an indication for invasive mechanical ventilation.[9]

Intubation and mechanical ventilation

At this point several precautions need to be taken while intubating the patient. Intubation is an aerosol generating procedure and hence should be a well-planned procedure.[10] If no isolation room or negative pressure room is available consider using the aerosol box.[11] It has to be a drug assisted intubation, make use of a video laryngoscope if possible.[12] A checklist is to be followed before entering the room for the procedure **(Figure 2 & 3).**

Invasive mechanical ventilation

We suggest the use of Assist control (Pressure or Volume) as the initial mode of ventilation in these patients. The initial parameters to set in a Volume Control mode are the tidal volume, fraction of inspired oxygen (FiO_2), Respiratory rate, inspiration expiration ratio and positive end expiratory pressure (PEEP).[13]

If the patient is presenting with the H phenotype (like classical ARDS) the usual lung protective ventilation strategy is the way to go.[14] The cornerstone of lung protective ventilation is low tidal volume targeted to

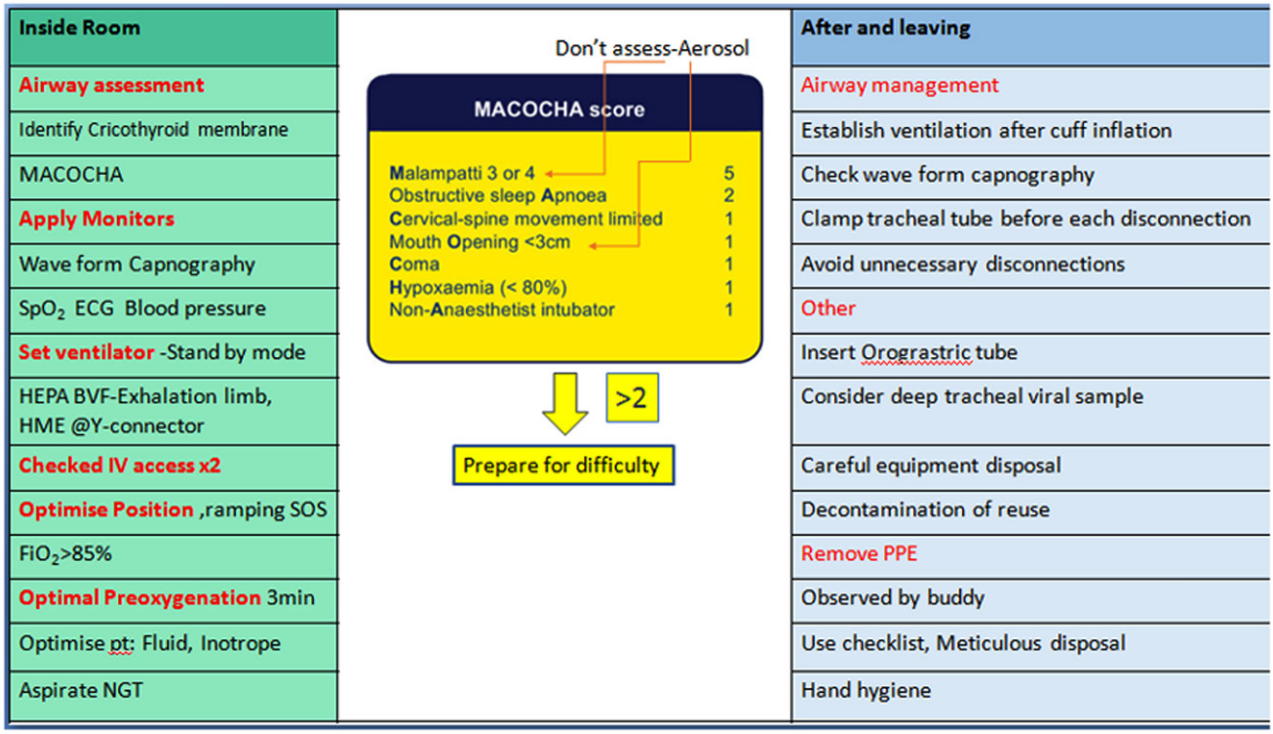

Figure 2. **Intubation: Checklist inside the isolation room**

Outside Room	Intubation check list Outside room	Outside Room
PPE- be thorough, don't rush	Check kit	If airway is difficult could we wake pt up?
Wash hands	BMV: Bains Circuit with BVF attached	What is the plan for a difficult intubation?
Long sleeved gown	Guedels airway, Bougie /Stylet	A: RSI
N95 mask	Working suction	B: 2 handed 2 person BMV
Glovesx2	Videolaryngoscope /McCoy/ Magills	C: 2G SGA
Eye wear	Aerosol box, HEPA BVF, HME	BMV ⟷ 2G SGA
Wipeable shoe	Two ETT, Ties, syringe, Cuff pressure monitor	D: FONA-Cricothyroidotomy, Scalpel bougie technique
Face shield	$EtCO_2$ 2G SGA	Confirm agreed plan
Allocate roles	FONA set (Needle Cricothyroidotomy)	Does any one have any concerns
Leader, Intubator	Zip lock cover for used Laryngoscope blade	
Cricoid-Assistant	Drugs	
Drugs, Monitor, timer	Ketamine, Scoline, Roc/Vec /Atrac	Mucous aspirator for deep tracheal sample
Runner (outside)	Vasopressor, Midazolam/Fentanyl/Dexem	Ryles tube/ freka
How to contact help	Weight? Allergies?	Central lines, Arterial lines, Foley

Figure 3. **Intubation: Checklist outside the isolation room**

Table 1. Predicted Body Weight (PBW)

Males	PBW= 50+2.3(Heigh t in inches – 60)
Females	PBW= 45.5+2.3(Height in inches – 60)

certain pressure limits like Plateau pressure and driving pressure. The tidal volumes that are used range from 4-8ml/kg (PBW) with the plateau pressure below 30 cm of water and driving pressure below 15cm of H_2O[15] **(Table 1).**

The L phenotype can be ventilated using tidal volume 6-8 ml/kg and at times to 8-9ml/kg particularly when the $PaCO_2$ levels are high as the lung compliance is normal in this Phenotype.[16]

After initiating mechanical ventilation at 8ml/kg tidal volume if the targets pressures are high it is an indication to decrease tidal volume to 6ml/kg. As we go on decreasing tidal volume the minute ventilation needs to be adjusted by increasing the Respiratory rate (to a maximum of 35). Otherwise it will result in respiratory acidosis **(Table 2).** Permissive hypercapnia to a pH of 7.2 may be tolerated but this can be deleterious in patients with pulmonary hypertension and right ventricular strain. Hence reserve this strategy to only when increasing the respiratory rate is not enough to prevent hypercarbia.

Table 2. Targets On Mechanical Ventilation

Oxygenation	SpO2 - 90-94 %, PaO2 - 60-80 mm of Hg
Safe pressure limits	Plateau Pressure<30 cm of H2O (Obtained with Inspiratory hold manoeuvre- reflects alveolar pressure) Driving Pressure <15 cm of H2O (Pplat-PEEP)
pH goal	pH 7.30 –7.45

As patient is hypoxemia to start with FiO_2 of 1.0 is used initially. Aim for saturation between 90-94% only and decrease the FiO_2 if the saturation is higher.

The Respiratory rate can be set at a higher rate than physiological if the patient is tachypnoeic to begin with and is readjusted based on $PaCO_2$ /End tidal CO_2 levels. The inspiration expiration ratio of 1:2 can be used as inverse ratio ventilation does not hold promise in ARDS ventilation.

The positive end expiratory pressure is one parameter that helps in improving oxygenation as it prevents the alveoli from collapsing at the end of expiration. Depending on the degree of hypoxemia and hemodynamic stability the positive end expiratory pressure may be set at 5-8 cm of H_2O during initiation and gradually increased if

Table 3. FiO2- PEEP - Move rightward if oxygenation goal not met (Lower PEEP/higher FiO2)

FiO2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12
FiO2	0.7	0.8	0.9	0.9	0.9	1.0		
PEEP	14	14	14	16	18	18-24		

Table 4. Initial settings and further modification needed to meet goals

Initial settings for a 50 kg male patient	Targets(if met continue the same setting)	If Targets not met
Mode VCV FiO2 1.0 Tidal volume 400 ml RR 16-26 PEEP 5-8 cm H2O	Plateau pressure < 30 Driving pressure < 15 SpO2 90-94% PaO2 60-80	Decrease TV by 2ml/kg Increase PEEP up to 15 if hemodynamically stable Neuromuscular blockade
	pH 7.3-7.45	Increase RR up to 35 if persistent respiratory acidosis

hypoxemia is not improving. Too much PEEP can also be detrimental as it can lead to hemodynamic instability and wasted ventilation. Hence the PEEP/FiO_2 scales from ARDS net guidelines can be used to adjust the PEEP **(Table 3).**

If the patient after optimizing ventilation is not improving:(PaO_2/ FiO_2< 150, PEEP around 15cm H_2O) Prone ventilation to be planned. Ventilation of the lungs in prone position is one way of recruiting larger volume of the lung. This will improve oxygenation. Prone ventilation is to be considered early in the course of the disease if patient remains hypoxemic for optimal results. According to the LUNG SAFE study last year only eight percent of ARDS patients are ventilated in prone position even though it is a very useful strategy. Patients who have refractory hypoxemia even after prone ventilation, active discussions with a centre with ECMO (extra corporeal membrane oxygenation) facility should begin **(Table 4).**

Other strategies (Suggested not recommended)

Recruitment manoeuvres can be resorted to before prone ventilation in the H phenotype. This has little role in the L phenotype. Stepwise gradual increase in PEEP is considered as an ideal recruitment manoeuvre. Abort recruitment if patient becomes hemodynamically unstable.

WHO recommends against administration of Steroids mainly extrapolating data from previous SARS CoV 1 and MERS CoV experience. But hitherto information from countries where SARS CoV 2 is spreading fast, Steroids as well as the anti-inflammatory agent Tocilizumab are to be used during the inflammatory phase of the disease which usually occur by the second week.

Other adjunctive measures

Inhaled Nitric oxide a pulmonary vasodilator improves oxygenation by preferentially dilating the well ventilated pulmonary vasculature. It is costly and can be used as a bridging therapy for patients awaiting extracorporeal membrane oxygenation **(Table 5).**

Table 5. Other adjunctive measures

Adjunctive measures	Uses
Broad spectrum antibiotics	Secondary infections
Diuretics	Dry lung strategy
Hydroxychloroquine+ Azithromycin	Prevents viral replication
LMWH-Enoxaparin BD	Pulmonary microthrombosis
Inj Methyl prednisolone1-2mg/kg/day InjTocilizumab	Cytokine storm

Weaning

COVID patients remain on ventilator for a considerable period and the median number of days is fifteen. Weaning is to be considered as the PaO2/FiO2 ratio improves more than 200 with the patient comfortable with reduced respiratory rate and alert on the ventilator. Such patients may be given Pressure Support ventilation trials or T tube trials. Patients tolerating these weaning trials can be extubated.

CONCLUSION

It is imperative to identify the two phenotypes of this disease more importantly the L phenotype. The ventilators management is different as this is not ARDS. The H phenotype can be managed like a conventional ARDS case. The outcomes from mechanical ventilation are not promising as of now but will definitely improve as the pandemic is progresses. This is a living document and guidelines can change as more studies come up.

END NOTE

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