



## Airway Management of COVID 19 and Low Cost Ventilators - A boon or bane

Shristi Verma\*

Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Sciences, Wardha, Maharashtra, India



### Article History:

Received on: 16 Nov 2020

Revised on: 09 Dec 2020

Accepted on: 14 Dec 2020

### Keywords:

Airway management,  
symptomatic treatment,  
COVID-19,  
mechanical ventilation,  
low-cost ventilator

### ABSTRACT

Corona viruses are a large group of infectants that caused illness in humans and animals. In human it spreads through contact between people which is observed with MERS and SARS. Close contact leads to the spread of this deadly virus through the droplets from cough, sneezes or talks. The incubation period ranges between 2-14 days which is still uncertain in many a lot of cases. Depending on the symptoms disease has been categorized for the management, thus mild symptoms with sore throat, fever, cough and malaise are treated with antipyretic and antitussives with nutritive care. For moderate symptoms oxygen therapy, Anticoagulation, corticosteroids is given with antiviral drugs, demand for the supply must be maintained. WRT the severe cases drug therapy should be continued and oxygenation maintained early in the disease, with the progression of disease to ARDS ventilation protocol is taken into action firstly with non-invasive procedure supplying oxygen by the mask or the nasal cannula and maintaining the SpO<sub>2</sub> and FiO<sub>2</sub>. If the condition worsens the Lung no longer acts compliant endotracheal intubation is performed for implementation of mechanical ventilation in the setting with access to expertise. For the patients who undergoes septic shock, patient is started on antimicrobial therapy, fluid loadings maintained and vasopressors given. Glucocorticoids can be used for short duration for the worsening condition of the patient. Their raised a situation of scarcity of ventilators, suddenly with the pandemic in the country alarming the under preparation of the demand for the present and future. Thus, by going local the ideology of low-cost ventilators happened.

### \*Corresponding Author

Name: Shristi Verma

Phone: 7875227384

Email: [shristi.verma26aug@gmail.com](mailto:shristi.verma26aug@gmail.com)

ISSN: 0975-7538

DOI: <https://doi.org/10.26452/ijrps.v11iSPL1.4135>

Production and Hosted by

IJRPS | [www.ijrps.com](http://www.ijrps.com)

© 2020 | All rights reserved.

## INTRODUCTION

### Pathogenesis of coronavirus

Initially the mortality rates estimated was about 2% which varies distinctly based on the age factor and the underlying comorbidities. Regrettably, 20% of the patients affected will develop respiratory infiltrates with severe illness as progressing towards the third stage of disease. Type 2 cells are infected the most in pneumocytes of alveoli, after virus invades the lungs. Peripheral and sub pleural alveolar units tend to be infected, where the Type 2 cells are contaminated advantageously in comparison to type 1 cell in both Severe Acute Respiratory Syndrome-Corona Virus and H1N1 influenza virus. Severe Acute Respiratory Syndrome CoV disseminates within type II pneumocytes, quiet a lot number of viral load released which undergoes apoptosis of cells. The type 2 cells are infected by viral par-

ticles in adjoining part where self-replicating pulmonary toxin is released. With the activation of epithelium by compensatory pathway, most regions of lungs will lose their type 2 pneumocytes. Presence of fibrin rich hyaline membrane with scattered alveolar worsening with a few multinucleated giant cells are observed pathologically both in Severe Acute Respiratory Syndrome and Cov19 patients, that ultimately leads to fibrosis due to wound healing which is atypical in nature, not seen in other forms of ARDS. Metamorphosis of epithelium and adaptive immunity is the key for recovery. There's increase in production of Angiotensin Converting Enzymes-2 cells due to growing viral count by administration of keratinocyte growth factors that helps in epithelial growth, alike H1N1 Influenza virus. There are a few classes like the geriatric group that stands at risk to regenerate the damaged epithelium and passage of infection to the lower compartment of lungs happening due to worsened mucociliary clearance and decreased immune response, thus spreading the infection more readily (Branson *et al.*, 2012).

#### **Airway management in cov 19**

Severe coronavirus disease 2019 has dominant feature of arterial hypoxemia exceeding difficulties in respiratory mechanics. A lot of patients which may range, approximately from 12% to 15% which are hospitalized require invasive ventilation via endotracheal intubation and many patients are placed on mechanical ventilation during the early period in their course. Usage of ventilators is increasing enormously in today's scenario, leading progressively towards a fear of unavailability in the future. To minimize the risk of disease transmission during this aerosol-generating procedure the exact need is preparing carefully the equipment's and medications necessary in the procedure which should be on hand, as well as an experienced intubation team who can overhaul many unanticipated obstacles.

One of the most critical procedure is the intubation of ET tube useful for management of unstable patients with COVID-19. Respiratory enrollment shows decrease in oxygen level and dissociation which is rapid in nature rapid observed during intubation. Intubation can be associated with hemodynamic compromise from sympatholysis, vasodilation, and myocardial depression caused by induction agents.

In studies which were held on patients suffering from severe COVID-19 infection showed the primary symptoms of distress in the respiration which occurred late, that is, around 7<sup>th</sup> day that increased rapidly within next 2 days. If the patient is intubated

on time, there's oxygen debt prevention by upgrading both breathing and oxygen supply.

Patient's oxygen supply more wisely known as oxygenation is checked very firstly a pulse oxymetre. True arterial oxygen saturation on the oximetry can differ from saturation by  $\pm 4\%$ . Because of the sigmoid shape of oxygen dissociation curve there's difficulty been arising in the explication of saturation readings above 90%. A value of 95% in the oximetry shows arterial oxygen tension which may range from 60- 200 mmHg due to the flatness of upper O<sub>2</sub> dissociation curve, thus most patients that receive a high concretion of oxygen that carry extremely different implication for management.

Pulmonologist or Intensive care giver when sees a patient can face major difficulties in including the arterial oxygenation if the supplemental oxygen has been already given. To overcome such problems one must acquire the understanding of fractional inspired oxygen concentration (fiO<sub>2</sub>) for the analysis of gaseous exchange. FiO<sub>2</sub> may range between 24% to 35% with 2L/min in a set of nasal cannula.

These recordings which includes PaO<sub>2</sub>, PaCO<sub>2</sub> and FiO<sub>2</sub> are a must for the calculation of alveolar to arterial oxygen gradient. Thus the division of PaO<sub>2</sub>/FiO<sub>2</sub> shows the changes in PO<sub>2</sub>, FiO<sub>2</sub> or both but for gain of pathophysiological basis of hypoxemia, the alveolar to arterial oxygen gradient is comparatively more specific.

Increased alveolar-to-arterial oxygen gradient alongside hypoxemia with Cov-19 shows intrapulmonary shunting or mismatch in the ventilation-perfusion, which is generally present with supplementation of oxygen seen in the patients with rise in PaO<sub>2</sub> level. Without the mechanical ventilation and ET intubation procedures an adequate level of arterial oxygenation is maintained. An intrapulmonary shunt can be detected by sudden rise in PaO<sub>2</sub> which do not fall with the supply of oxygen, this overall promotes the usage of invasive ventilator assistance headway in such patients (Tobin, 2020).

When a patient starts of said oxygen therapy, their requirements always tend to go up irrespective of their oxygen consumption measurement clearly stating supplementation of oxygen demand in such patients has elevated. Patients who are on mechanical ventilation belongs to group where there's increased chances of cardiac arrest are present (Chahar *et al.*, 2020).

#### **What is mechanical ventilation?**

It is used to assist or replace spontaneous breathing with the help of physical devices or machines when a patient a in dire need, during any surgical procedure

or critical illness. Patient is placed on venti when there's need for protection against aspiration in the airway, when the patient suffering from hypoxic respiratory failure and need high level of inspired oxygen, to relieve obstruction from upper airway and when there's hypercapnic respiratory failure causing need for assisted ventilation.

### There are two types of mechanical ventilation

- The non-invasive technique where there's no insertion of any tube in the air passage of the patient whose.
- The invasive procedure comprising ventilation of patient by invading the trachea with a tube insertion and then connecting it to the ventilator usually come into play for lungs that are weaker, ARDS lungs or neuromuscular weakness causing nonfunctional chest wall ([Javed and Farrukh, 2019](#)).

### Symptomatic treatment

Depending on the severity of the clinical features patients are categorized into certain categories and managed accordingly,

#### Mild Symptoms

Patient presented with uncomplicated upper respiratory tract infection comprising cough, hyperthermia, pain in the throat, blockage in the nose, headache, restlessness, no breathlessness presence in this case.

#### Management

To prevent the further spread of virus patient is being isolated, patients detailed history should be taken with essential past history of any comorbidities present or not for close monitoring and deterioration of possible risks involved with the same. Should be monitored for signs and symptoms of any difficulty that should need urgent management.

They are given,

1. In the presence of mild symptoms antipyretic in hyperthermia and pain, antitussives for cough.
2. Patient should be properly hydrated and appropriately provided with nutrients.
3. Tab hydroxychloroquine considered for any of those high risk patient under strict medical supervision, preferably after shifting to DCHC.
4. Restriction towards the patient of cardiac arrest, history of unexplained syncope or QT prolongation(480m) for prescribing HCQ.

With the probability of 50% progression of disease in patients, if shows any worsening symptoms like mental confusion, persistent pain or pressure in the chest, difficulty breathing, dehydration, decreased urine output, bluish discoloration of face, lips or skin; one must be equipped with admission procedure in DCHC for further management

### Moderate symptoms

Pneumonia with no signs of severe disease where, Adults are present with decreased breathing, hyperthermia, cough, including saturation of oxygen pressure <94% on room air, Respiratory Rate >= 24 per minute.

Children are present with hypoxia, fast breathing ranges (age below 2 months: >= 60; age ranging between 2-11 months: >=50; aged between 1-5 years: >=40), cough including saturation of oxygen <94% on room air, RR more or equal to 24/min.

Such patients are isolated in DEDICATED COVID HEALTH CENTRES or DISTRICT HOSPITAL or Medical College Hospitals. Detailed clinical history should be taken with further investigation like Chest X-ray, CBC and oxygen saturation. Prescription of the antimicrobial should be restricted till the suspected cause of infection comes out to-be bacteria.

1. Symptomatic t/t with paracetamol and
2. Adequate hydration
3. Oxygen Therapy

-Target SpO<sub>2</sub>: 92-96% (88-92% in patients with COPD) –

Oxygen masks, nasal prongs or masks in breathing or non-breathing reservoir bags should be taken into consideration depending on the demand for oxygen in therapy.

Application of N95 mask is a must on the simple nasal cannula or High Field Nasal Cannula.

-In case any emergency arises, the rescuer must go for awake proning.

1. Anticoagulation - Prophylactic dose of UFH or LMWH (e.g., enoxaparin 40 mg per day SC)
2. Corticosteroids - Consider IV methylprednisolone 0.5 to 1 mg/kg OR Dexamethasone 0.1 to 0.2 mg/kg for 3 days
3. Antivirals- Tablet Hydroxychloroquine with a dose of 400mg BD on 1st day followed by 200mg 1 BD for 4 days. (After ECG Assessment).
4. Control of co-morbid condition.

5. Check for levels of CRP, D-dimer & Ferritin every 48-72 hourly (if available); Complete Blood Count with differential leucocyte count, Absolute Lymphocyte count, Kidney Function Test/ Liver Function Test daily.
6. Record the following:
  - Use of accessory muscles showing increased work of breathing.
  - Abnormal blood pressure.
  - Demand for the requirement of oxygen increased.

Patient if showcases any of the mentioned, must be shifted to Dedicated Covid Health Centre.

### Severe Symptoms

Severe pneumonia, adolescents or adults presents with respiratory rate >30/min, SpO<sub>2</sub><90% on room air and severe respiratory distress.

Children shows features like difficulty in breathing and cough, also any one of the following may be present central cyanosis or SpO<sub>2</sub><90%, severe respiratory distress encasing grunting, chest in drawing, inability to breastfeed, easy fatigability or unconsciousness or convulsions when present with signs of pneumonia ([Miesbach and Makris, 2020](#)).

### Management

Monitoring of patient and early supportive therapy,

1. Symptomatic treatment with paracetamol and antitussives to continue
2. Oxygenation: Severe Covid or Pulmonary distressed, Hypoxemic or Patient under shock should be started with Oxygen: Reach the SpO<sub>2</sub> ≥ 90 % in non-pregnant adults and ≥ 92 to

96% in pregnant adults with titrate flow and therapy initiated at 5 L/min. Target the SpO<sub>2</sub> ≥ 94% in case of children's present with severe respiratory distress, obstructed breathing, coma or convulsions which highlights the emergency of situation. Certain precautions on contact are mandatory while handling the interfaces of COVID-19 patients which gets contaminated. Properly equipped areas with simple face mask (single use disposable), nasal cannula (single use disposable), pulse oximeters, face mask and reservoir, functioning oxygen system for severe COVID patients.

1. If the patient is not in shock, conservative method of fluid management is implicated.

2. Under surveillance to the high risk of bleeding, dose of UFH/ LMWH (ex, Enoxaparin 40mg BD SC) can be given for anticoagulation.
3. Corticosteroids which can be administered like IV Methylprednisolone with a dose of 1-2 mg/kg or Dexamethasone 0.2-0.4 mg/kg for 5-7 days.
4. Investigational therapy: Tocilizumab

### Management of ARDS and Hypoxemic respiratory failure

When a patient doesn't respond to standard oxygen therapy, might suffer from increased work of breathing given by face mask at with reservoir bag.

There's a protocol been allotted for lung protective ventilation,

Tidal volume 6ml/kg, RR-16-35/min, PEEP-5-15 cm of H<sub>2</sub>O, target SpO<sub>2</sub>- 88 to 95% and/or PaO<sub>2</sub>- 55 to 80 mmHg.

### Non-invasive mechanical ventilation or High - Flow Nasal cannula Oxygenation (HFNO)

It helps in the reduction of usage of intubation. Patients with hypercapnia, hemodynamic instability, multi organ failure, abnormal mental status must not be provided with HFNO but it can be provided to the patient with mild and moderate also non-invasive hypercapnia. Monitoring of patient is a must for at least 1 hour by experienced personnel who's capable of

ET intubation, in case any emergency arises.

Non-invasive ventilation: setting - PS 5-15 cmH<sub>2</sub>O adjusted to tidal volume of 5-7 ml/kg and PEEP 5-10 cm H<sub>2</sub>O and FiO<sub>2</sub> @ 0.5 -1.0 titrated to target SpO<sub>2</sub>> 94%.

### Points to be remembered

Expert should do the ET intubation under the cautious airborne terms. Children, pregnant or obese patients may get de-saturated easily during intubation. To avoid such consequences, one must pre-oxygenate with face mask with reservoir bag at 100% FiO<sub>2</sub> for 5 minutes with face mask with reservoir bag.

With lower tidal volume, ie, 4-8 ml/kg predicted body weight and lower inspiratory pressure, mechanical ventilation should be performed. It's given for sepsis induce respiratory failure patients as well. 6ml/kilogram tidal PBW is the initial tidal volume which can range to 8ml/kilogram on the counter of undesirable side effects. The pH goal of 7.3 to 7.45 must be achieved for permitting hypercapnia. Target tidal volumes should be achieved

with the help of deep sedation to control respiratory drive.

16 to 18 hours of mechanical ventilation is required in patients with severe ARDS in a day which ultimately requires sufficient human resources and expertise.

High PEEP is suggested instead of low PEEP for patients with moderate or severe ARDS. With access to the known individuals of extracorporeal life support in the settings, despite of ventilation by protection of lung should be considered with reference to refractory hypoxemia patients. Authorized centers should provide adequate case volume for maintaining the expertise wrt, ECLS and can require COVID 19 application of IPC measures.

In the disconnection of ventilator there's loss of PEEP and results in atelectasis which should be avoided. In line catheters are helpful for clamp ET tube and airway suctioning, if requirement is disconnection ([Einav and Leone, 2019](#)).

### Management of septic shock

- Detection of such patients.
- Vasopressors needed to maintain mean arterial pressure.
- Use MAP and clinical signs of perfusion for the measurement of absence of lactate for defining shock. Early recognition and following treatments within one hour of recognition is required as standard care: antimicrobial therapy and fluid loading and vasopressors for hypotension. If the patient is in need of central venous and arterial catheters, then only it should be used.
- First of all; starches, hypotonic crystalloids or gelatin should not be used for resuscitation. In adults, dose of 30ml/kg of isotonic crystalloid for 3 hours and in children, 20ml/kg as rapid bolus up to 40-60 ml/kg in first hour should be given on resuscitation.
- If patient shows jugular venous distension, crackles on lung auscultation in adults and hepatomegaly in children, these signs of volume overload with no response to fluid loading, fluid administration should be discontinued or reduced, specially when mechanical ventilation is not available. Some cases shows respiratory failure on volume overload in fluid resuscitation.
- On the basis of clinical response and improvement of perfusion targets need for the additional fluid boluses should be determined, like

adults 200 to 1000ml and children 10-20 ml/kg. Normal saline and Ringer's lactate are the crystalloids been used.

### Other therapeutic measures

When the condition of patient is deteriorating drastically with decreasing immune responses, the images of C-X-ray is getting worsened, decrease in oxygen indicators; usage of glucocorticoids for 3-5 days which should not exceed the equivalent of methylprednisolone 1-2 mg/kg/day or dexamethasone 0.2-0.4 mg/kg/day. Must remember the immunosuppressive effect of glucocorticoids while its administration leading to delay in the removal of corona virus.

Detailed analysis of underlying comorbidities should be checked repeatedly. For anticoagulation UFH and LMWH should be prescribed prophylactically critical Gravid cases, consultation is a must with psychiatrist, obstetrician, pediatrician and intensive care specialist ([MoHFW, 2019](#)).

### "Low cost" made in india ventilators, boon or bane?

Government came forward in this brink of a time with the idea, when the pandemic hit the country and hospitals raised the alarming need of ventilators which stood 47,000 in number, to go local for the manufacturing of low cost ventilators. Companies like AgVa Healthcare and state owned Bharat Electronics Ltd/ BEL were placed an order of 10,000 to 20,000 each as the imports were costly and difficult given global travel restrictions.

In the month of May, a total of 16 local companies were contracted for manufacturing of

60,000 cost-effective ventilators in 2 months. It allotted 20 Billion rupees from the PM CARES fund to purchase these machines. The high end ventilators which the doctors used earlier costed 1.5 to 2 million rupees whereas the AgVa ventilators are priced at 150,000 rupees and BEL's machine are priced at 400,000 rupees each.

Due to this short timespan manufacturers sped up production and cut costs by skipping more advanced features. Lok Nayak Jai Prakash Hospital, Delhi's largest for covid 19 care after receiving 175 ventilator (155 from BEL and 20 from AgVa) said last week that the machines did not have BiPAP, a key non-invasive option to supply oxygen without intubation.

Many senior consultants reported the use non-invasive technique at first in case of mild to moderate cases until the patient is on the verge to not breathe by own self, to prevent damage from the

invasive procedure in the early course. According to today's scenario, most patients in India do not need invasive ventilation and are treated with non-invasive technique only, until the situation gets worsened.

Major hospitals in Mumbai were also supplied with same where the doctors of JJ group of hospitals complained that AgVa ventilators do not have control knob to set the fraction of inspired oxygen, i.e., FiO<sub>2</sub>. Without this, doctors have to manually change the right proportion of oxygen in the air being supplied to the patient and the air pressure at the end of exhalation and inhalation. A ventilator without control button for the oxygen level and pressure could harm a patient seemingly low-end and are totally unacceptable. 81 machines were returned back to AgVa Manufacturers with the opinion to not stand the critical care of Covid patients.

A report from Mumbai doctors sent to medical education and research suggested that AgVa machines were incapable of reaching the targeted oxygen saturation and indicate the actual level of FiO<sub>2</sub> delivered to the patient. Patients showed signs of improvement when shifted to other ventilators who were showing the signs of restlessness and exhaustion with local ventis.

The co-inventor of AgVa ventilator and a Neurologist stands by their machine stating, someone donated our low-end model of ventilators to Mumbai hospitals. These don't have built-in oxygen blenders, but are perfectly suitable for covid care intubation. A third party technician's improper demonstration and installation led to the dissatisfaction of doctors."

To which an official from sir JJ group of hospitals responded by a report that brought forth deficiencies that "cannot be simply attributed to improper installation". In the month May technician had visited to upgrade the software in some machines, but control settings they needed for oxygen therapy were available only in the next advanced version, a letter from Medical superintendent, and doctors in St. George hospital stated.

An interventional cardiologist who evaluated the BEL ventilators explained, that Non-invasive option (BiPAP) was grandeur and not a standard requirement by technical committee and would have also prolonged the making while India was panicking about not having enough ventilators. Chances are aerosolisation at a very high intensity in BiPAP by the mask through which Covid patient gets oxygen, spreading it to the medical staff taking care of them in the modern scenario of Air conditioned with no windows Intensive care units, in the form of droplets from the holes present in mask. This ultimately

raised a question regarding the usage of which type of ventilators best suitable both for the patients as well as the medical staff and if Indian government overestimated the country's need for them, as with the evolvement of pandemic more doctors are using non-invasive technique for treatment.

Data reported by a Mumbai based consultant respirologist states that, on the deterioration of corona infected patient the lungs are compliant even when the body think it needs oxygen, then the only requirement is to fulfil the demand for oxygen and let patient breathe better, further, intubation is only required if the patient arrives late with Acute Respiratory Distress Syndrome.

Overall most critical care medical professionals insisted on the presence of both non-invasive and invasive recourse of the care of Covid-19 patients. BEL and AgVa representatives are speaking with hospitals concerned and trying to explore the upgraded versions of the same.

Earlier due to this alarming pandemic condition which then stated the shortage of ventilators, has now turned into trouble due to the overabundance of manufacturing of more than 60,000 ventilators, turned out not so reliable for the current situation by the doctors. Winded Indian manufacturers now hope that foreign markets with shortages will buy their ventilators.

With the concluding statement based on database from June 23<sup>rd</sup>, 2020, showcased by the Health Ministry of India, asserted, only 4.16 percentile of infected Covid patients required ventilators whereas the need for oxygen stood a 16 percentage (Dasgupta and Mohan, 2020).

## RESULTS AND DISCUSSION

Management of airway in covid 19 patients requires a stratified plan where a treatment should be provided based the nature of disease progressing towards the uphill or downfall of the patient. Detailed History and high risk patients should be examined thoroughly with investigational as well as therapeutic management, where ever required the demand of oxygen must be prioritized with the finest equipped criteria with the oxygen therapy or the ventilation methods. In country's scenario at present where the Ministry of health showcased astounding data of patients getting better with the non-invasive procedure itself, there's no need of invasive mechanical ventilation ultimately throwing light on the failed decision by Government for panic manufacturing of low cost ventilators, which anyways lack a few advanced features thus making it

surplus in number rather than demand.

Certain interventions are required to prevent the disease in the early stage to decrease the loss of opportunity, generated for saving the patients towards the progressing critical illness. At the earliest one must go through history of the patient with all the key points like, travelling or comorbidities. Thorough examination will reveal the type of protocol under which patient will be treated based on the manifestation of infection. There are few complications which may arise if the outcome is unexpected, so one must prevent by anticipating it, like, by the reduction of invasive mechanical ventilation which can be achieved by weaning protocols to let the patient breath spontaneously also minimizing the intermittent sedation by interruption of sedative infusion. Reduce the incidence of ventilator associated pneumonia by oral intubation instead of nasal in adolescents and adults, keep patient in semi-recumbent position, use close suctioning system with periodic draining and discard condensate in tubing. There may also arise the incidence of ICU-related weakness which should be prevented by actively mobilizing the patient early in the course of illness when it is safer to do so.

When it comes to the usage of invasive procedure for covid 19 patients, the low cost ventilators fate remains up in the air as first of all the situation of patients seems to be under control with the non-invasive technique, failing the judgement predicted at the start of pandemic by the government, on running out of ventilators with the increase in corona infected cases and second reason due to which it got rejected by 4 major hospitals in India, is it lacks an essential feature which leads to the control of oxygen level and pressure at the press of a button that ultimately causes damage to the patients (MoHFW, 2019).

## CONCLUSION

Thus, prevention of disease at the earliest staging is considered to be condemnatory step. But one must be prepared with further for any kind of mishap in the manifestation of disease progressing towards the complication. Usage of invasive procedures like mechanical ventilation and non-invasive procedure like oxygenation by nasal cannula must be used effectively, depending the potential of patient with respect to response towards the treatment provided. With the unpredictability of future in context to the disease, it will be beneficial if the nation is prior hand prepared with manufactured low-cost ventilators.

## Conflict of Interest

The authors declare that they have no conflict of interest for this study.

## Funding Support

The authors declare that they have no funding support for this study.

## REFERENCES

- Branson, R. D., Blakeman, T. C., Robinson, B. R., Johannigman, J. A. 2012. Use of a Single Ventilator to Support 4 Patients: Laboratory Evaluation of a Limited Concept. *Respiratory Care*, 57:399–403.
- Chahar, P., Dugar, S., Marciniak, D. 2020. Airway management considerations in patients with COVID-19. *Cleveland Clinic Journal of Medicine*.
- Dasgupta, D., Mohan, R. M. R. 2020. Fate of India-made ventilators up in the air as non-invasive treatments become main mode of care. *The Straits Times*. [Accessed On July 10, 2020].
- Einav, S., Leone, M. 2019. Peri-operative adverse respiratory events and post-operative non-invasive ventilation. *Journal of Emergency and Critical Care Medicine*, 3:46–46.
- Javed, D., Farrukh 2019. Mechanical Ventilation. Health & Medicine. *Slide Share*. [Accessed On May 30, 2019].
- Miesbach, W., Makris, M. 2020. COVID-19: Coagulopathy, Risk of Thrombosis, and the Rationale for Anticoagulation. *Clinical and Applied Thrombosis/Hemostasis*, 26:107602962093814–107602962093814.
- MoHFW 2019. The updated case definitions. National Centre for Disease Control Directorate General of Health Services. GOI, New Delhi. *Ministry of Health and Family Welfare*.
- Tobin, M. J. 2020. Basing Respiratory Management of COVID-19 on Physiological Principles. *American Journal of Respiratory and Critical Care Medicine*, 201(11).