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EC PHARMACOLOGY AND TOXICOLOGY
Review Article

How to Treat Covid-19-Related Pneumonia Patients with a Ventilator?

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Received: April 30, 2020; **Published:** June 30, 2021

Abstract

The first cases of a novel virus, called COVID-19, were documented in Wuhan, on December 2019. According to Gattinoni, two different phenotypes can be found in COVID-19-related pneumonia. Both phenotypes show a different Pathophysiology, which can be detected from the moment the patient is admitted to the hospital. 70% of those cases featured Phenotype 1, where pulmonary compliance was higher than 50 ml/cmH_2O, while 20% were presented with Phenotype 2 with a pulmonary compliance lower than 50 ml/cmH_2O. The use of a CT scan is paramount for early detection and pulmonary compliance measurements must be performed, as soon as the patient is connected to a mechanical ventilator. These procedures allow physicians involved to start treatment and protect the lungs. Among other parameters, a tidal volume of 6 ml/kg and a PEEP of 8 - 10 mmHg should be used when dealing with Phenotype 1, whereas Phenotype 2 should be treated to certain point as an Acute Severe Respiratory Distress Syndrome. This article strives to show the sequential algorithm for this methodology, so that these guidelines are available for all treating Physicians that could encounter this type of patients in the future.

Keywords: *Covid-19; Pneumonia; Ventilator*

Introduction

The first series of cases of a novel acute respiratory failure were documented in Wuhan, the capital city of the Chinese province of Hubei, on December 2019; this syndrome was initially called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), due to etiological organism found in its structure. On February 2020, the World Health Organization (WHO) officially named the respiratory illness caused by the SARS-CoV-2 virus, as coronavirus disease 2019 (COVID-19). The disease rapidly spread to Wuhan's outskirts, surrounding cities and, finally across the world [1,2]. The first case in Mexico City was documented on February 29, 2020. As of April 21 2020, 8772 confirmed and 9653 suspected COVID-19 cases, as well as 712 disease-related deaths were reported in Mexico [3].

COVID-19-related pneumonia is a two-phenotype-specific disease, where treating Physicians need to know the phenotype distinction to treat infected patients with assisted ventilation, if necessary. As a main feature, severe hypoxemia is often considered unrelated to assisted ventilation in cases where both phenotypes are found [4].

How can the medical staff differ from phenotype 1 and 2?

According to Gattinoni, both phenotypes found in Acute Severe Respiratory Distress Syndrome show different Pathophysiology characteristics, which can be detected from the moment the patient is admitted to the hospital or once there is a COVID-19 prognosis; therefore, the use of a CT scan is paramount for early detection (Figure 1). In case a CT scan is not available, there are other procedures to identify and measure the levels of pulmonary compliance within the respiratory system, as well as any potential PEEP response. The levels of

pulmonary compliance within the respiratory system is around 50 ml/cmH_2O, which is the baseline measurement value for patients with assisted ventilation; when there is inspiratory pause, patients with lower or higher pulmonary compliance values to the mean levels will suffer from equally severe hypoxemia. Features from each phenotype are explained in the following section (Table 1) [4,5].

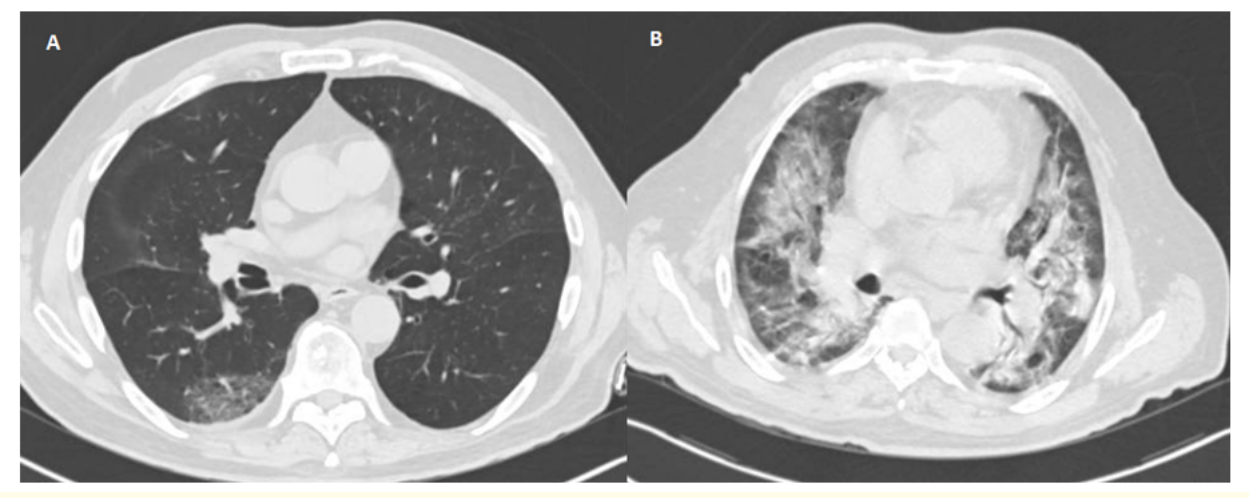

Figure 1: *A: Phenotype 1: distensibility of elastic tissue, ventilation/perfusion ratio, lung weight, decreased alveolar recruitment. B: Phenotype 2: distensibility of elastic tissue, ventilation/perfusion ratio, lung weight, increased alveolar recruitment.*

	Type 1	Type 2
Distensibility of elastic tissue	Decreased. These compliance levels indicate that the amount of lung gas is close to normal levels.	Increased. A decreased edema-related gas volume results in an increased distensibility of elastic lung tissue.
Ventilation/perfusion ratio (VA/Q)	Decreased. With gas volume close to normal levels. Hypoxemia is caused by the losses of regulated profusion and hypoxic vasoconstriction. At this stage, the levels of pulmonary artery pressure should be close to normal.	Increased. This is caused by the cardiac output, perfusing non-air-containing tissues, that is developed in parts of the lung, due to the increased edema and overlapping pressure.
Lung weight	Decreased. During a CT scan, frosted glass densities can be detected in subpleural tissue and lung crevices.	Increased. CT scanning shows a significant lung weight increase (> 1.5 kg)
Alveolar recruitment	Decreased. The amount of non-air-containing tissue is very low and thus, alveolar recruitment is also very low.	Increased. An increased amount of non -air-containing tissue is associated to a higher alveolar recruitment, such as severe ARDS.

Table 1: *Features of both types of Gattinoni's phenotypes.*

Phenotype 1

Patients with close-to-normal levels of pulmonary compliance and Isolated Viral Pneumonia. In 70% of the ITU cases, Hypoxemia is associated to patients with pulmonary compliance of > 50 ml/cmH_2O. The values of lung gas volume are high, levels of alveolar recruitment are low, and hypoxemia is probably derived from vasoconstriction and a loss of the regulated blood flow. Severe hypoxemia is caused by a disturbance in the ventilation/perfusion ratio (V_A/Q). Placing patients in prone position has beneficial results in increasing PEEP levels,

as this readjusts the levels of pulmonary perfusion and improves the ventilation/perfusion ratio (V_A/Q). Patient CT scanning proofs that there are no significant areas for alveolar recruitment [4].

Phenotype 2

20% of the severe-hypoxemia-related cases are associated to patients with pulmonary compliance of < 40 ml/cmH_2O, which are directly related to ARDS. It is possible that low compliance results from a natural evolution of the disease; nonetheless, there is rebuttal evidence that the increase in negative effects could be caused by the airway management. In fact, some hypoxemic patients that were treated with non-invasive assisted ventilation before they were admitted showed significant inspiratory efforts, evidence of respiratory failure and an increase in negative intrathoracic pressure. Therefore, apart from suffering viral pneumonia, these patients developed lung injuries as a result of the assisted ventilation [6,7].

Clinical application of gattinoni's phenotypes

After the CT scan is able to identify the phenotypes, measures in response to the use of assisted ventilation must be taken, whenever possible, to avoid delaying any potential benefit resulting from the treatment (Figure 2). In case the ER or the first-contact health services collapse due to the number of patients, non-invasive assisted ventilation is a good alternative for first-line treatment that can be used in critical and non-critical care units and it should ideally be used to measure blood gases in such patients. The key to treatment with assisted ventilation for these patients consists in measuring expiratory efforts and inspiratory work levels. Any sign of inspiratory effort should be carefully assessed, as any clinical evidence of respiratory failure would result in tracheal intubation to avoid or limit Phenotype 1's transition into Phenotype 2 resulting from ventilator-induced lung injuries. In case high-flow nasal cannula is chosen to avoid as much as possible the use of a mechanical ventilator, the ratio of oxygenation should be assessed by measuring oxygen saturation from inspiratory and expiratory oxygen levels, via an oximeter, which should be documented 2, 6 and 12 hours after and in case there is evidence of patient clinical deterioration. While a value of > 4.88 means that there is low possibility of requiring invasive assisted ventilation, a <3.85 value results in a high possibility of performing tracheal intubation and being treated with all the resulting and aforementioned measures [8].

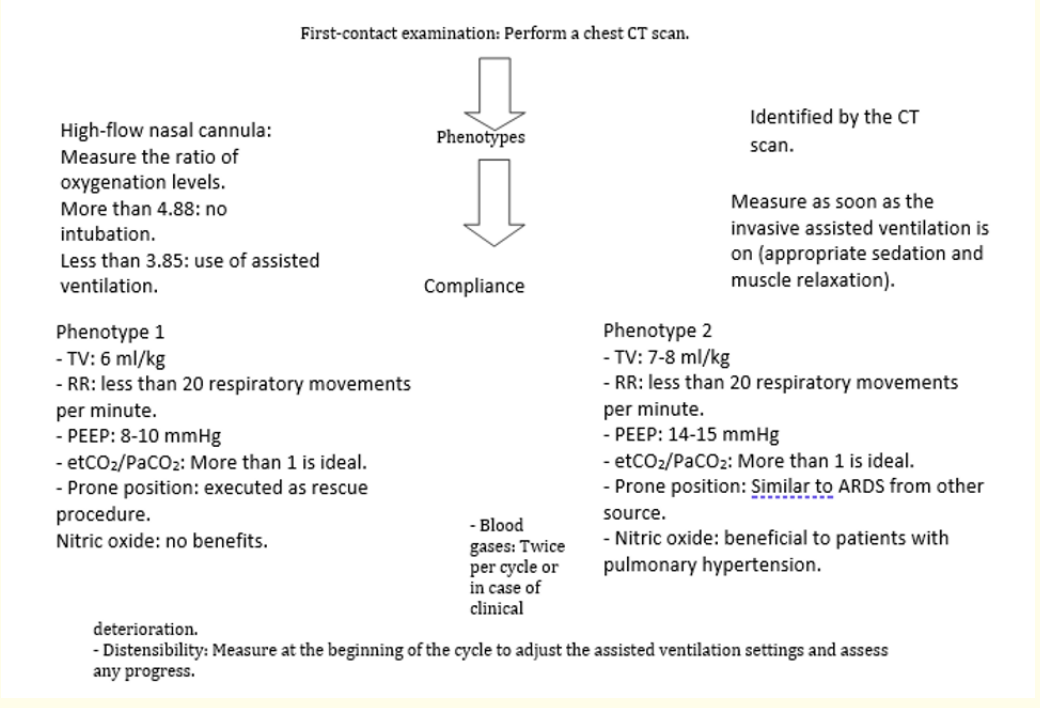

Figure 2: *Treatment algorithm for COVID-19 patients that require invasive assisted ventilation.*

Conclusion

It is important to consider that most of these patients shall be admitted to non-critical care units; therefore, all Physicians involved must be notified that the guidelines for the ventilator parameters are based on Gattinoni's remarks on these phenotypes. The ventilator's target settings are listed in the following chart (Table 2) [9-11].

	Type 1	Type 2
Tidal volume (TV)	A ventilator-induced lung injury can be caused when low compliance values and an increased driving pressure are detected, derived from adjusting TV higher than 6 ml/kg and setting the respiratory rate to 15 – 20 per minute.	Low tidal volume. The use of TV of 7 - 8 ml/kg can foster the presence of atelectasis and hypercapnia.
PEEP	Adequate PEEP levels of 8-10 cmH_2O, higher levels could have a deleterious effect in the proper functioning of the right ventricle. An EKG must be used to measure the functioning of the right ventricle when the PEEP levels increase.	Gradually setting PEEP levels between 14 and 15 cmH_2O could be beneficial for the patient. At this stage, decreasing SvO_2 is not recommended and could cause an inefficient cardiac output. Therefore, increased PEEP levels should not be used during long periods of time.
Shunts	The best tool to assess oxygenation levels is shunt calculation (parts of the air-containing and non-perfused lung)	$etCO_2/PaCO_2$ ratio measures the efficiency of pulmonary gas exchange. A value of < 1 suggests that there is an increase in shunt and dead space levels
Prone position	This should be done as a rescue procedure to ease pulmonary flow reallocation, instead of opening collapsed areas. However, using this has little benefit.	Prone position is used the same way in any type of ARDS.
Nitric oxide	There is no evidence that this is useful in treating stroke patients.	In this scenario, it could be beneficial to stroke patients with pulmonary hypertension.

Table 2: *Guidelines for patients treated with assisted ventilation.*

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Volume 9 Issue 7 July 2021