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EVALUATION OF RESPIRATORY MECHANICS OF PATIENTS WITH COVID-19 ADMITTED TO AN INTENSIVE CARE UNIT

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ABSTRACT

This retrospective study analyzed the ventilatory mechanics of patients with COVID-19 in mechanically ventilated ICUs, correlating variables such as PEEP, VT, and SAT with length of hospital stay, mechanical ventilation, and probability of death. Using patient records, between April 2021 and April 2022, the analysis took place on the 1st and 5th day of mechanical ventilation, with tests such as Wilcoxon and Spearman's correlation. Of the 20 medical records, most patients were female (57.16%) and had comorbidities (60%). There were few changes in VT and PEEP, but a significant change in SAT during hospitalization. The strong correlation between intubation time and total length of hospital stay suggests an associated prolongation. The results highlight the importance of targeted interventions for severe COVID-19 patients in ICUs, considering the relationship between partial improvement of the SAT and unfavorable outcomes related to prolonged duration of mechanical ventilation and hospitalization.

Keywords: Mechanical Ventilation. COVID-19. Length of Hospitalization.

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INTRODUCTION

COVID-19 is an infection caused by the virus called SARS-CoV-2, commonly known as the "new coronavirus", which is capable of promoting from asymptomatic to highly severe infections, causing high mortality rates (BRASIL, 2020). The clinical picture can be easily confused with a flu-like syndrome and can progress to its more severe presentation, including septic shock and respiratory failure (CHAN et al., 2020).

Currently, in Brazil, the number of deaths caused by COVID-19 is 710,174, which is considered a high mortality rate. The total number of cases of the disease, identified in the country as of February 24, 2024 is 38,521,738, with an incidence of 18330.8. The main region with the highest number of cases and deaths is the southeast region, with 15,362,101 cases and 341,951 deaths (BRASIL, 2024).

The most common alterations observed in complementary exams are bilateral infiltrates in imaging exams, reduction in total lymphocyte count in the blood count, and elevated values of C-reactive protein. In its most severe phase, the infection can promote severe complications in the respiratory system, such as Pneumonia and Acute Respiratory Distress Syndrome (ARDS) (BRASIL, 2020).

Upon entering the individual's respiratory system, the virus can lead to the destruction of the lining cells of the bronchi and alveoli (NEGRI, 2021). In this context, the treatment for severe ARDS resulting from infection involves the need for invasive treatment measures, such as intubation and invasive mechanical ventilation (GRASSELI et al., 2021).

The main objective of mechanical ventilation is to enable rest for the respiratory muscles, in order to reduce the ventilatory work, determined in oxygen cost (TOBIN et al., 2001). Ventilatory support of the respiratory system is one of the pillars of intensive care, being an important resource in the treatment and control of SARS-CoV-2 in its severe form, in which more than 70 million infected people worldwide required this mechanical support for ventilation (GRASSELLI et al., 2021; WHO, 2020).

To achieve the objectives related to the use of mechanical ventilation, it is important that the adjusted parameters promote effective care. Enabling a minimum work that avoids muscle atrophy and provides improvement to the patient, promoting early weaning. Thus, it is essential to periodically evaluate the respiratory mechanics of these patients in order to understand their evolution (JUNIOR; CARVALHO, 1992).

Knowledge about respiratory mechanics makes it possible to use more effective parameters to promote better adjustments in mechanical ventilation, in order to avoid possible lung injuries (GARCÍA-PRIETO et al., 2014), in addition to helping to choose the most appropriate physical therapy intervention to treat patients on ventilatory support

(FAUSTINO, 2007). Monitoring respiratory mechanics provides understanding to understand ventilatory dynamics and optimize ventilatory support (FERNANDES, 2006).

Thus, the monitoring and recording of compliance and resistance in the respiratory system in patients on ventilatory support enables a longitudinal comparison of these variables over the period in which the patient remains on mechanical ventilation in the Intensive Care Unit (JUNIOR et al., 2020).

Monitoring and analysis of the mechanics of the ventilatory system make it possible to assist in the clinical and functional diagnosis of pulmonary diseases, in addition to facilitating the understanding of ventilatory dynamics in patients admitted to the Intensive Care Unit under invasive mechanical ventilation. Thus, knowledge of ventilatory mechanics enables health professionals to adjust ventilatory parameters in an appropriate and/or "protective" manner based on the condition of each patient on ventilatory support, in order to prevent the worsening or appearance of lung lesions (SADDY, 2011).

In view of the above, this study aims to analyze the ventilatory mechanics of patients with COVID-19 admitted to an Intensive Care Unit under Invasive Mechanical Ventilation and to describe the behavior of the ventilatory mechanics variables: Positive Expiratory Pressure (PEEP), Tidal Volume (VT) and Saturation (SAT). As well as correlating the length of hospital stay with the duration of mechanical ventilation (MV) and the higher probability of death.

METHODOLOGY

This is a retrospective, descriptive, cross-sectional, documentary-based study carried out at the Santa Casa de Misericórdia Hospital in Patos de Minas. Medical records of patients admitted to the Intensive Care Unit of the aforementioned hospital, undergoing treatment for Covid-19, between April 2021 and April 2022, were analyzed. The project was submitted to the Research Ethics Committee of the University Center of Patos de Minas – CEP – UNIPAM and was approved according to opinion number 5.331.458.

As inclusion criteria, complete, legible medical records, duly recorded with the signature and stamp of the professional at each consultation, of individuals of both sexes hospitalized for COVID-19 in the Intensive Care Unit who underwent intubation and Invasive Mechanical Ventilation, were selected. The medical records of patients under 18 years of age or those of patients who were admitted to the Intensive Care Unit for noninvasive mechanical ventilation were excluded.

Initially, the selection of the medical records was carried out upon confirmation of the inclusion criteria of the study. It was verified through the application of an evaluation and data collection form, written by the authors themselves, in which information related to the patient's hospitalization was collected, such as: presence of associated pathologies, sociodemographic, clinical, laboratory, ventilatory and functional information.

Data regarding respiratory mechanics (tidal volume, positive end-expiratory pressure, and saturation) and the patient's clinical condition were analyzed on the 1st day of hospitalization on the 5th day of hospitalization.

For data analysis, the Wilcoxon test was performed, and ventilatory parameters were measured at two different times. Values were expressed as median and interquartile range (Q1 and Q3). Spearman's correlation test was used to analyze the length of hospital stay and the total length of stay. A value of $p<0.05$ was adopted as statistically significant.

RESULTS AND DISCUSSION

The sample consisted of 20 medical records of patients diagnosed with COVID-19 admitted to the hospital, 40.38% of whom were male and 57.16% female, in addition to 60% of the sample had comorbidities, data presented in Table 1.

Table 1- Distribution of COVID-19 patients' comorbidities related to sex

	MEN	WOMEN
SEX	8 (40%)	12 (60%)
HAS+DM	4 (20%)	8 (40%)
HAS	4 (20%)	8 (40%)
DM	2 (10%)	6 (30%)

Legend: SAH: Systemic Arterial Hypertension; DM: Diabetes Mellitus.
Source 1: Authorship

The data suggest a trend toward a higher incidence of COVID-19 infections among women compared to men. This possible disparity may be supported by the results of the 2022 Population Census (BRASIL, 2022), which reveals a surplus of 6.0 million women compared to men in Brazil. The country's total population is about 104.5 million females and 98.5 million males, accounting for 51.5% and 48.5% of the population, respectively. This demographic difference may contribute to variations in infection rates between genders.

These data reinforce the conclusions of the study by Machado, Batista, and De Souza (2021), who, when conducting an epidemiological investigation in the state of Bahia in 2021, found a prevalence of confirmed cases in females (54.63%), surpassing males (45.19%). This trend is also corroborated by the study by Almeida et al. (2020), whose objective was to analyze the epidemiological profile in the state of Maranhão. In this study, the authors observed a higher prevalence of infections in females (52%), compared to males (48%). This converging evidence highlights the possible disparity in the incidence of COVID-19 infections between genders in different regions of Brazil.

With regard to the comorbidities present in the study participants, hypertension and diabetes were found to be among the main causes, in line with the results of a meta-analysis conducted in China (WANG et al., 2020). This meta-analysis showed a significant increase in the risk of worsening in individuals with hypertension and diabetes. Another study, published in the journal *Archives of Internal Medicine* of the Polish Society of Internal Medicine, highlighted that hypertension is associated with an almost 2.5 times higher risk for developing the severe form of COVID-19, in addition to increasing the probability of mortality (LIPPI, WONG, HENRY; 2020). These findings underscore the importance of considering these comorbidities as significant risk factors in the context of COVID-19 infection.

The variables analyzed in Table 2 were the Tidal Volume (VT), which represents the total amount of air inhaled and exhaled in a respiratory cycle; the Positive End-expiratory Pressure (PEEP), which has the importance of presenting a residual positive pressure in the alveoli at the end of expiration, aiming to prevent alveolar collapse and improve gas exchange; and Oxygen Saturation (SAT). indicating the amount of hemoglobin impregnated by oxygen, providing a representation of the oxygenation rate in the tissues. (VALIATTI et al., 2022).

Regarding mechanical ventilation data, ventilatory parameters were recorded at two different moments: on the first and fifth days of mechanical ventilation. Consistency was observed in the VT and PEEP variables between the first and fifth days of mechanical ventilation. However, a significant increase in the SAT over the course of hospitalization stands out, as detailed in Table 2.

Table 2 - Parameters analyzed in relation to the 1st and 5th day of mechanical ventilation.

Parameter	Day 1	Day 5	*p*- value
YOU	400 (335 – 447)	385 (340 – 472,5)	0,434
PEEP	12 (12- 14)	12 (10 – 14)	0,558
SAT	90 (84,750 – 92)	92,5 (90 – 94)	<0.015 *

Source 2: Authorship by the author.

The values were presented as median and interquartile range (Q1 and Q3). The results indicated the absence of a significant difference in VT (p=0.434) and PEEP (p=0.558) between the two moments evaluated. However, a statistically significant difference was observed in the SAT (p=0.015), suggesting a change in the efficiency of oxygenation over time, with an increase in the median SAT from the first to the fifth day. These variables play a crucial role in understanding patient outcomes during mechanical ventilation, providing valuable insights for therapeutic adjustments and clinical monitoring.

Ensuring the continuous supply of oxygen to cells, in response to their metabolic needs, is a vital function of the cardiorespiratory system. Under normal conditions, the supply of oxygen is regulated by a process known as "demand-driven supply." In several diseases, it is necessary to intervene in the variables that affect systemic oxygen transport to adjust supply according to metabolic demand (ASSOBRAFIR, 2020).

Hypoxemia in patients with COVID-19 can be attributed to a number of factors, including the formation of intrapulmonary shunts, dysregulation of pulmonary perfusion, occurrence of intravascular microthrombi, impairment of diffusion capacity, and altered preservation of lung mechanics (LANG et al., 2020; Tay et al., 2020; Liu et al., 2020; Ackermann et al., 2020).

According to the Brazilian Guidelines for the Hospital Treatment of Patients with COVID-19 (2021), the oxygen saturation goal (SpO_2) is between 90% and 94%. According to the guidelines, for patients who are in this range without showing signs of respiratory distress, the conduct is to maintain treatment. If the SpO_2 is in this range and the patient does not have discomfort, it is recommended to decrease the amount of oxygen administered (BRASIL, 2021).

The results of this study revealed a significant improvement in the oxygen saturation of the patients analyzed. However, it is important to note that these results did not investigate the underlying causes of this improvement. It is believed that this improvement may be related both to the treatment of the infection and to the implementation of techniques aimed at improving the ventilatory capacity of patients. These techniques may include: alveolar recruitment, PEEP titration maneuver, and prone position.

The analysis between the time of intubation and the total length of hospital stay is shown in Table 3, which presents the results of Spearman's correlation It is observed that Spearman's correlation coefficient (rô) between the variables is 0.919, which indicates a very strong positive correlation. This means that the longer the intubation time, the longer the total length of stay. In addition, the p-value (sig. 2 extremities) is 0.000, which indicates that the correlation is statistically significant at the level of 0.01.

Table 3 – Spearman's correlation between intubation time and total length of hospital stay.

VARIABLE	**N**	Correlation coefficient
Intubation time	20	1,000
Total length of hospital stay	20	0,919**

Source 3: Authorship
** The correlation is significant at the 0.01 level (2 ends).

It was observed through this result that the length of hospital stay in this population is directly related to the time of intubation, and the longer the intubation time, the longer the length of stay. The decision on when to start mechanical ventilation in patients with COVID-19 pneumonia is challenging, especially in the early phase of the disease, when patients may have normal lung mechanics. This can make it difficult for clinicians to choose mechanical ventilation, as discussed by Pfeifer et al. (2020).

One of the hypotheses to explain this finding is that intubation of patients with COVID-19 may require more time than usual in a standard intubation setting. This is because an additional period is required for the intubation team to equip themselves with the appropriate personal protective equipment and to transfer the patient to an appropriate location, following strict infection control measures. These delays due to complex procedures can result in a prolonged period of hypoxemia, and patients may worsen before they receive mechanical ventilation. This, in turn, can lead to increased morbidity, mortality, and length of hospital stay (FAYED et al., 2021).

Another hypothesis may be related to the study by Vera et al. (2021), whose objective was to determine whether time to intubation was associated with higher ICU mortality in COVID-19 patients on mechanical ventilation due to respiratory failure, the authors found that patients intubated after 48 hours had an ICU length of stay of approximately 7 days, however, a hospital stay longer than 5 days has been reported to be associated with an elevated mortality rate.

Like Bavishi et al. (2021), in their retrospective cohort study, whose objective was to investigate the variation in outcomes and respiratory mechanics among individuals who were intubated earlier or later during the course of the coronavirus disease in 2019, the authors also observed that patients intubated early had a significantly shorter mean hospital stay, although there were no significant differences in the length of ICU stay and the duration of mechanical ventilation.

The study by Correa et al. (2021) corroborates the findings of these studies by observing that ICU [20 (13-32) versus 5 (2-8) days; p<0.001] and hospital stay [27 (17-41) versus 10 (7-15) days; p<0.001] were longer in patients who required mechanical ventilation compared to those who did not. The authors also highlighted a correlation between length of hospital stay and a higher mortality rate. However, they did not present a hypothesis that would justify the prolongation of the length of hospital stay associated with the prolonged use of invasive mechanical ventilation.

One of the limitations of this study includes the sample size, which was justified by the absence of data in the medical records analyzed, resulting in the exclusion of some patients from the data analysis. In addition, no data were collected related to ventilatory mechanics and interventions performed during the hospitalization period of the patients analyzed, which may have influenced the results of the study

CONCLUSION

Based on the findings of this study, it can be concluded that there was a significant improvement in peripheral saturation over time, indicating an efficiency of oxygenation. In addition, it was observed that the increase in intubation time is associated with an increase in the total length of hospital stay. Although these data may be related to late or early intubation, there is no direct evidence in this study to support this theory. Therefore, it is recommended to conduct further retrospective studies to investigate the hypotheses raised in this study and provide a more comprehensive understanding of the factors influencing peripheral saturation and length of hospital stay in COVID-19 patients.

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