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Non-Invasive Ventilation in Combination with Prone Position in the Treatment of Acute Respiratory Failure Associated with COVID-19

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Abstract

To evaluate the effect of prone position in patients receiving non-invasive ventilation with COVID-19. The severe form of COVID-19 cause's respiratory symptoms in a significant number of patients, requiring more active intervention. In all countries, since the disease was first identified, it has been recognized that a large number of patients with severe COVID-19 disease develop Acute Respiratory Distress Syndrome (ARDS) and require respiratory support. Initial treatment for severe respiratory distress included early intubation and invasive ventilation as it was considered more effective than Non-Invasive Ventilation (NIV). NIV includes Continuous Positive Airway Pressure (CPAP) and Bi-Level Positive Airway Pressure (BiPAP). A prone position in combination with NIV can improve oxygenation in COVID-19 patients. This can be achieved without significant side effects and, in particular, in patients with a sustained response, intubation can be avoided.

Keywords: Non-invasive ventilation; Prone position; COVID-19; Continuous positive airway pressure

Introduction

The severe form of COVID-19 causes respiratory symptoms in a significant number of patients, requiring more active intervention. In all countries, since the disease was first identified, it has been recognized that a large number of patients with severe COVID-19 disease develop Acute Respiratory Distress Syndrome (ARDS) and require respiratory support. Initial treatment for severe respiratory distress included early intubation and invasive ventilation as it was considered more effective than Non-Invasive Ventilation (NIV). However, an analysis of foreign literature and our numerous experience of working with COVID-19 patients showed that NIV can play a more significant and positive role than was initially assumed [1,2].

NIV includes Continuous Positive Airway Pressure (CPAP) and Bi-Level Positive Airway Pressure (BiPAP). CPAP is the BiPAP method of choice for people with complex respiratory conditions who have contracted COVID-19. There are two types of NIV. The first mode is Continuous Positive Airway Pressure (CPAP), which creates a single pressure during inspiration and expiration. During CPAP application there are small fluctuations in inspiratory and expiratory pressure. When you inhale, the pressure drops, and when you exhale, it increases. CPAP is most effective for patients with hypoxemic respiratory failure. It can be assumed that CPAP is similar to Positive End Expiratory Pressure (PEEP) during mechanical ventilation with endotracheal intubation. BPAP is a two-level pressure applied during inspiration and expiration. Inspiratory Positive Airway Pressure (IPAP) is pressure support applied during inspiration, while Expiratory Positive Airway Pressure (EPAP) is pressure applied during inspiration and expiration. EPAP, CPAP and PEEP are similar in this respect. NIV reduces the work of breathing by counteracting internal PEEP, promotes alveolar recruitment, reduces shunt, and improves ventilation and perfusion. NIV also improves alveolar gas exchange and removal of carbon dioxide, and also reduces oxygen consumption by the intercostal muscles. NIV increases the pressure inside the chest. This increase in pressure can inhibit venous return (preload) and, by reducing cardiac after load, acts as an adjunct to the left ventricle. These physiological changes are the mainstay of NIV for the treatment of pulmonary edema, although in patients with preload, increased intrathoracic pressure may cause hypotension [3-5].

Critically ill patients hospitalized after infection with COVID-19 often have hypoxic respiratory failure, and some require invasive mechanical ventilation to maintain adequate oxygenation. The

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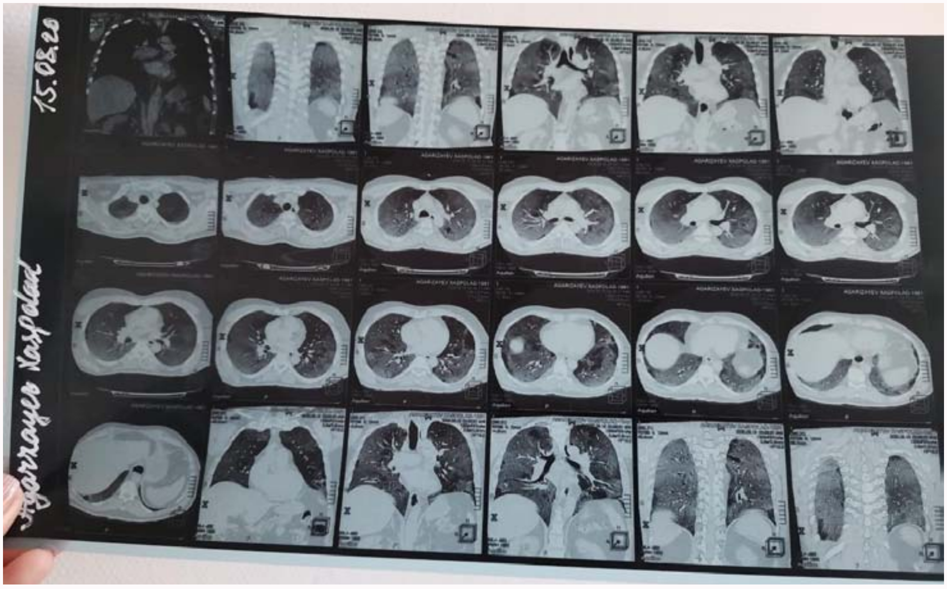

Figure 1: Computed tomography of the patient's chest in dynamics.

combination of prone position and non-invasive ventilation in awake patients may play a role in improving oxygenation [6-9]. The use of the prone position for COVID-19 - associated pneumonia is supported by our understanding of the pathophysiology of the disease. There is heterogeneity in the lungs, and CT scans of COVID-19 patients usually show areas of peripheral ground glass changes that later develop into linear indurations. Areas of exudation, macrophage infiltration, fibrosis, and mucous plugs are typical autopsy findings in deceased COVID-19 patients. Placing patients in a supine position can facilitate the drainage of secretions from the periphery of the lungs; improve pulmonary heterogeneity, recruitment, and ventilation/perfusion mismatch [10-15].

Materials and Methods

The study was carried out at the AMU Surgical Clinic and at the Baku City Clinical Medical Center from April to September 2020. The average age was 59 years (± 13 years). Non-invasive ventilation was used in 92 patients, of whom 52 were men and 40 women with moderate or even severe ARDS, whose oxygen saturation dropped below 88% to 64% when using mask oxygen therapy with a high concentration of O_2, using the CPAP (constant positive airway pressure) 10 to 15 sm.w.a. And 60% to 100% Fraction of inspired Oxygen (FiO_2). In the case of an unsatisfactory response to NIV, we performed NIV in the prone position, in which the treatment was continued, if there was a positive trend in the first hour. Non-invasive ventilation cycles were individualized depending on the severity of the patient's condition, patient compliance with the treatment regimen, and the onset of dyspnea during the period without NIV. We assessed oxygen Saturation by pulse Oximetry (SpO_2), calculated the respiratory index PaO_2: FiO_2, and assessed respiratory rate and patient comfort using a numeric rating scale (0 - completely uncomfortable, up to 10 - completely convenient). Follow-up evaluations were performed over 28 days to determine how many patients were discharged, remained in prone position, or were intubated.

Patients received NIV with prone sessions after a poor response to Continuous Positive Airway Pressure (CPAP) at 10 cm H_2O. Compared to previous NIV use, oxygenation and respiratory rate improved during NIV in the pronation position (PaO_2: FiO_2, 60 to 200) increased to 200, and the respiratory rate of 35 breaths/min decreased to 24 [21-25]. breaths/min) and also remained improved 1 h after the session in the majority of patients 75. After 14 days, five patients were intubated and another died. Many, but not all, patients with hypoxemic respiratory failure tolerate prone position well during wakefulness, spontaneous breathing, or non-invasive ventilation. Among patients who underwent the prone position session, there was an improvement in oxygenation and a decrease in respiratory rate, which indicates a lower respiratory intensity (respiratory rate is weakly correlated with the activity of the respiratory center, but in this context it is potentially associated with a lower intensity). These effects were transient - both respiration rate and oxygenation frequently returned to baseline after supination. The total time spent in the prone position was approximately 16 h to 20 h daily (including 8 h to 10 h during sleep at night) and was interrupted only by meals and short pauses for physical therapy. The patient never complained of severe shortness of breath, but nevertheless he noted that he felt better in pronouncing. Prone position gave cyclical improvements in oxygenation. Prone position made it possible to achieve a more even distribution of lung tissue between the dorsal and ventral axes, which led to a more uniform alveolar architecture. Moreover, it also contributed to a more even distribution of pulmonary perfusion. It is likely that both of these changes reduced the local V/Q heterogeneity and improved oxygen saturation in the prone position. Improving oxygen saturation can also restore hypoxic pulmonary vasoconstriction, which is impaired at lower oxygen saturation levels, further improving V/Q mismatch.

Results

Compared to baseline, all patients showed a decrease in respiratory rate during and after pronation ($P<0.001$), all patients had an improvement in SpO_2 and PaO_2: FiO_2 during pronation ($P<0.001$). Within 14 days, 64 patients were discharged home, 20 continued pronation for 24 days, 5 patients were intubated and 3 patients died.

Our results demonstrate, inter alia, that sustained response over multiple cycles over a period of >20 h is associated with successful NIV

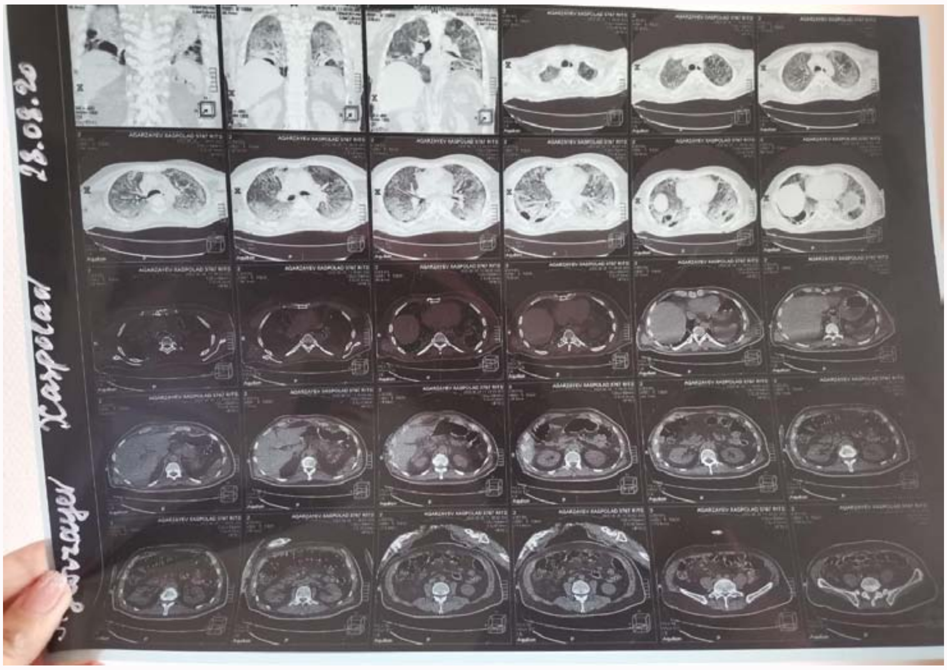

Figure 2: Different view of computed tomography of the patient's chest in dynamics.

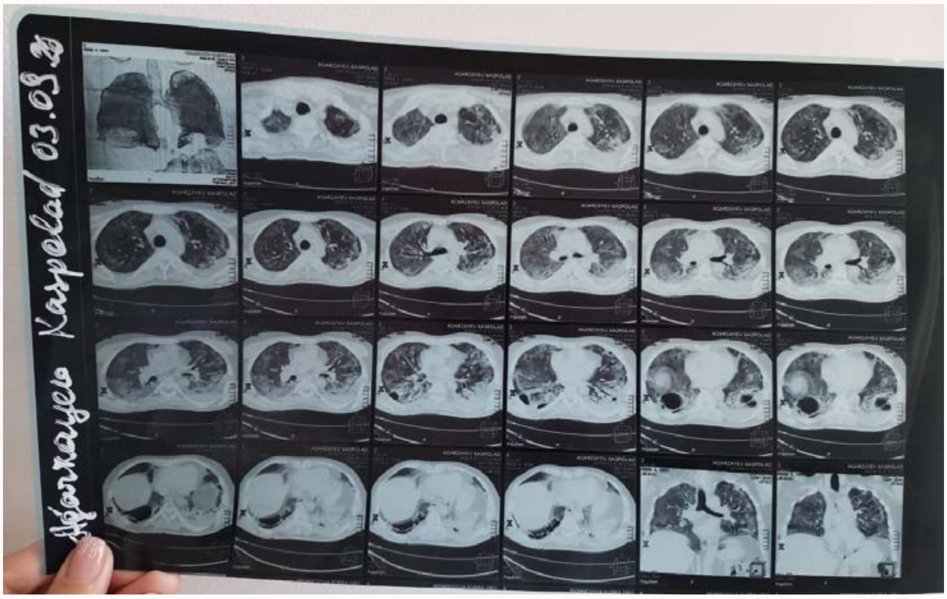

Figure 3: The patient was discharged on the 28th day with improvement.

treatment. Taken together, these results indicate that recumbency in awake, non-intubated patients, combined with non-invasive ventilation, is possible and could be considered an early intervention for COVID-19 respiratory failure, especially in the context of a severe pandemic to prevent mechanical ventilation and its subsequent complications. They also suggest that loss of response to the supine position could potentially be a sign of NIV failure and requires early evaluation and consideration of endotracheal intubation.

Discussion

The patient is a 59-year-old man with complaints of intermittent chronic cough, temperature 39.3°C, chills, headache, shortness of breath, loss of appetite, and loss of the sense of smell. On auscultation of the lungs, crepitus, moist rales in the lower lobes of the lungs, oxygen saturation 67% to 82%, and respiratory rate 28 to 35 per minute were noted. Laboratory tests on admission included: WBC - 17.42×10^9/L, LYM - 0.51×10^9/L, albumin - 3.01 g/dL, PI - 51.9%, PT - 14.8 sec., INR - 1.39, Fibrinogen - 128 mg/L, GRP 123.4 mg/L, D-Dimer >7500 ng/mL, Ferritin - 1435 ng/mL, P/F >85. Computed tomography of the patient's chest in dynamics are shown in the following (Figures 1-3).

Non-invasive ventilation of the lungs was carried out with an oral-nasal mask using a BIYONET ventilator. The parameters were set and adjusted according to the general state and according to blood gas data 4 times a day: RR<35, pH>7.30, neurological dysfunction according to the Kelly scale >3 to 5, modified with a scale for determining the participation of auxiliary respiratory muscles <3 points. With hypercapnia, the following parameters were set: Ps - 12, PEEP - 12 cm water column, FiO_2 - 30% to 40%, and with hypoxemia-Ps - 12 to 15, PEEP - 10 cm to 15 cm water column, FiO_2 - 60% to 80%. The median treatment period with NIV was 22 days. The average daily treatment time with NIV on the first day was 16.5 h, on the second day - 20.2 h and on the third day 15.7 h. The patient was discharged on the 28th day with improvement.

Conclusion

A prone position in combination with NIV can improve oxygenation in COVID-19 patients. This can be achieved without significant side effects and, in particular, in patients with a sustained response, intubation can be avoided. When used in an appropriately controlled environment with access to experienced clinicians able to facilitate invasive mechanical ventilation as needed, prone position next to NIV can be a useful tool in the management of COVID-19 patients even with severe acute hypoxic respiratory failure.

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