Original Article

Immediate Effect of Therapeutic Positioning and Breathing Exercises on Oxygen Saturation in Critically Ill Non-intubated COVID-19 Patients: A Retrospective Study

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ABSTRACT

Background: COVID-19 presents with symptoms of fever, headache, dry cough, and dyspnea. Acute hypoxemic respiratory failure is the most common complication occurring in 60%–70% of patients admitted to the intensive care unit (ICU). Positioning and breathing exercise formed the mainstay of physiotherapy intervention in patients admitted to COVID ICU. This was primarily aimed at reducing the ventilation/perfusion mismatch. The aim of this study was to retrospectively analyze the immediate effect of breathing exercise and positioning on oxygen saturation (SpO_2). **Materials and Methods:** The available data of COVID-19 patients admitted to an ICU of a tertiary care hospital in Mumbai from June 5 to July 5, 2020 were retrospectively analyzed. Demographics and mode of oxygen delivery were noted. Changes in SpO_2 after positioning and breathing exercises during a single session of treatment were analyzed using Wilcoxon paired signed-rank test with a level of significance at $P < 0.05$. **Results:** There was a statistically significant improvement in SpO_2 after breathing exercises and prone positioning in all patients on oxygen supplementation. Side-lying positioning showed an improvement in oxygen saturation in patients who were on non-invasive ventilation and facemask. **Conclusion:** Both breathing exercises and positioning show an immediate improvement in oxygen saturation in patients with COVID-19.

Keywords: *Breathing exercises, COVID-19, Oxygen saturation, Positioning, Proning*

Introduction

The novel coronavirus (nCoV-2019) from Wuhan, China, in December 2019 was declared as a global public health emergency by the World Health Organization (WHO), which impacted many lives and the global economy.[1] This disease in its varied form presented with pneumonia and acute respiratory distress syndrome (ARDS). Acute hypoxemic respiratory failure was the most common complication occurring in 60%–70% of patients admitted to the intensive care unit (ICU).[2] High resolution computed tomography (HRCT) findings most commonly reported bilateral, multilobar ground glass opacities predominantly seen in lower lobes and the presence of consolidative opacities.[3] In severe cases, extensive involvement of the lung parenchyma, an impaired pulmonary diffusion, and ventilation/perfusion (V/Q) mismatch were evident on CT scan along with patients presenting as ARDS required hospitalization and immediate oxygen and ventilatory support.[4-6]

Physiotherapy is considered an integral part of critical care management. The preliminary data suggest a beneficial effect observed with physiotherapy intervention using positioning, breathing exercise, and early mobilization.[7]

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The most common positions used in this study were side-lying and prone to enhance ventilation/perfusion matching. It was observed that because of discomfort and nausea in the prone position, an alternative position, i.e., right and left decubitus, can also be given in patients having obesity or gastroesophageal reflux disease.[7-9]

In non-intubated patients with COVID-19, prone positioning together with a combined strategy of a high-flow nasal cannula and restrictive fluid or non-invasive ventilation (NIV) improved oxygenation.[10] The prone position is known to have better aeration of dorsal areas, relieves the lung segment from the compression caused by the heart's weight and abdominal cavity, and aids in the homogenous distribution of the ventilation.[8] It is recommended to maintain this position for 12–16h in those unable to maintain saturation. Awake prone positioning has been advocated to become standard of care for suspected or confirmed COVID-19, in patients requiring an $FiO_2 \geq 28\%$.[11] As a physiotherapeutic protocol, physiotherapists generally facilitate maintaining a therapeutic body position for a period of 15–30min along with breathing exercises. Whether maintenance of position for such short periods has any impact on saturation in COVID-19 patients is not known. Also, studies have reported the impact of breathing exercise on saturation in chronic heart failure.[12] Whether a similar effect is obtained in patients with COVID-19 is uncertain. Hence, the aim of this study was to retrospectively analyze the immediate effect of breathing exercise and positioning on oxygen saturation in non-intubated COVID-19 patients.

Materials and Methods

The study was approved by the institutional ethical committee. Following the ethical clearance, the electronic data record sheets of all patients who were confirmed on laboratory diagnosis as COVID-19 positive and needing oxygen support via facemask (FM), NIV, or non-rebreathing mask (NRBM) from a single COVID ICU of a tertiary care hospital in Mumbai from June 5 to July 5, 2020, were retrieved. Records of those patients with baseline saturation between 85% and 95% were retrieved for analysis. Records of intubated or unconscious patients or those who were not referred for physiotherapy, those with saturation >95%, and incomplete data were excluded. Daily parameters related to physiotherapy intervention of positioning and breathing exercises were extracted by a blinded assessor to a comprehensive data extraction sheet.

The following data were gathered from the record forms:

1. Demographic profile including age, gender, disease severity stage,
2. Mode of respiratory support and oxygen requirement,
3. Position given and breathing exercise,
4. Heart rate (HR) and oxygen saturation (SpO_2) with every intervention.

Data of oxygen saturation pre- and post-positioning and breathing exercises of a single session on day 2 of admission were analyzed for uniformity of interventions and to reduce physiological variability.

Statistical analysis

Data were presented as mean ± SD and were analyzed separately depending on the type of oxygen support, i.e., NIV, NRBM, or FM. Patient records were divided into two groups having baseline oxygen saturation between 85%–90% and 91%–95%. The change in HR postintervention was analyzed using paired t-test. The saturation difference post breathing exercises and between side-lying and prone positions was analyzed using Wilcoxon paired signed-rank test. The level of significance was set as $P < 0.05$.

Results

A total of 254 patient records were screened from June 5 to July 5, 2020. Out of which 112 records (83 males and 29 females) were included in the study and were analyzed, and the rest were excluded because of incomplete data. The mean age was 53.87 ± 15 years. 33.92% of patients were on FM, 50% on NRBM, and 15% on NIV. The mean HR preintervention was 92.91 ± 16.09 bpm, and postintervention it was 93.90 ± 18.38 bpm. The change in HR was not statistically significant. Side-lying as a therapeutic position was given to 38.39% ($n = 43$) patients and 61.60% ($n = 69$) received prone. The minimum time of maintaining a therapeutic position was 30min. There was a significant improvement in saturation as seen in Table 1 with prone positioning in all three groups (FM, NRBM, and NIV), whereas, with side-lying positions, it significantly improved in patients on FM and NIV. There was no significant change with the side-lying position in those on NRBM. There was an average increase in saturation by 2% in side-lying position (pre: 93.51% ± 3.69% and post 95% ± 3.18%) and by 3% in the prone position (pre: 92.17% ± 3.23% and post: 95.73% ± 2.7%) when patients being provided with oxygen supplementation by all three methods were considered together.

As seen in Table 2, there was a statistically significant improvement in the saturation by 4% after breathing exercises in the patients with a baseline saturation range of 85%–90% in all the three groups (FM [$P = 0.0010$], NRBM [$P = 0.0187$], and NIV [$P = 0.0034$]). The saturation improved by 2% in those with baseline saturation (91%–95%) and was also found to be statistically significant (FM [$P \leq 0.0001$], NRBM [$P = 0.0479$], and NIV [$P = 0.001$]).

Discussion

Therapeutic positioning and breathing exercises forming the mainstay of the physiotherapeutic regime were analyzed. Body positioning given for a duration of 30 min in both side-lying and prone improved saturation significantly in both NIV and FM groups. This change may be attributable to the movement of edema away from the areas dependent on gravity. Physiological changes are mediated by compression and gravity. Positioning the patients with good lung down minimizes the ventilation–perfusion mismatch and improves the gas exchange process, thereby improving saturation. This would be beneficial in ameliorating hypoxic vasoconstriction, thereby reducing pulmonary vascular resistance and improving right ventricular function.[13] The baseline oxygen saturation in the NRBM group was more than 95% indicating good oxygenation. The pulse oximeter is insensitive at the upper end of the curve, and any further difference in improvement was not obtained; hence, it showed statistically insignificance.

The results of prone positioning suggested that the difference was statistically significant in all the three groups. This significant difference could be attributable to the greater surface area of the lungs posteriorly. Studies also suggest that there is a decrease in the transpulmonary pressure gradient between the dependent and the non-dependent lung regions in the prone position, thus creating a uniform distribution of air. This causes recruitment of the collapsed alveoli, thereby improving V/Q matching. The alveoli once recruited are likely to remain open for a prolonged period of time, thus improving overall oxygenation.[14] The duration of 30 min seemed adequate enough for the maintenance of oxygen saturation. However, whether the saturation was maintained for a longer period of time is not known as sequential changes in saturation were not noted.

Changes in the lung parenchyma in patients with COVID-19 result in increased respiratory rate, HR, blood pressure, and reduced oxygen saturation. Controlled breathing exercise recruits the diaphragm, which is the main inspiratory muscle resulting in an increase in tidal volume, decreased functional residual capacity, and an optimal increase in oxygen intake.[12,15] Also, controlled breathing helps to maintain alveolar patency, recruits collapsed alveoli, and improves overall lung compliance. These physiological changes, in turn, augment an increase in oxygen saturation as seen in this study. Deep breathing for 2–5 min has been found to have an acute beneficial effect on lung function ability shortly after being given so that it can affect the oxygen saturation values.[16]

A decrease in HR has been reported after seven sessions of slow breathing exercises;[17] however, we did not find any change in HR. This could be because it was only one-time study. Voluntary deep breathing modulates the autonomic nervous system dynamically. It generates two physiological signals. First, it activates stretch receptors of the lungs and increases the frequency

Table 1: Change in oxygen saturation after positioning in patients on oxygen supplementation via FM, NRBM, and NIV ($n = 112$)

Mode of O_2	n		Side-lying Mean ± SD	P value	n	Prone Mean ± SD	P value
FM	10	Pre	90.8 ± 3.15	0.0164*	28	91.25 ± 3.06	<0.0001*
		Post	93 ± 3.88			95.28 ± 2.03	
NRBM	24	Pre	95.37 ± 2.96	0.7584	33	94.36 ± 4.19	0.0342*
		Post	95.58 ± 2.93			95.90 ± 3.37	
NIV	9	Pre	91.55 ± 3.39	0.0156*	8	92.125 ± 1.88	0.0078*
		Post	95.66 ± 2.23			96.625 ± 1.30	

*Statistically significant

Table 2: Change in SpO_2 after breathing exercises in patients on oxygen supplementation via FM, NRBM, and NIV

Variable	Range of baseline SpO_2 and mode of O_2	$n = 83$	Preintervention, mean ± SD	Postintervention, mean ± SD	P value*
SpO_2 (%)	FM, 85%–90%	11	87.63 ± 1.80	90.54 ± 2.16	0.0010*
	FM, 91%–95%	27	93.14 ± 1.48	95.03 ± 1.91	<0.0001*
	NRBM, 85%–90%	7	87.57 ± 1.90	92 ± 4.28	0.0187*
	NRBM, 91%–95%	20	92.55 ± 0.88	93 ± 3.44	0.0479*
	NIV, 85%–90%	3	88 ± 2.0	90.66 ± 1.15	0.0034*
	NIV, 91%–95%	13	93.07 ± 1.38	95.07 ± 1.89	0.0010*

*Statistically significant

and duration of inhibitory neural impulses during inhalation above tidal volume. Second, it increases the generation of hyperpolarization current by stretching connective tissue (fibroblasts) localized around the lungs. The inhibitory impulses, produced by slowly adapting receptors in the lungs during inflation, play a role in controlling typically autonomic functions such as breathing pattern, airway smooth muscle tone, systemic vascular resistance, and HR.[18] Synchronization within the hypothalamus and the brainstem is likely responsible for inducing the parasympathetic response during breathing exercises facilitating oxygenation. Also with an increase in alveolar volume, there is a reduction in dead space ventilation and dead space to tidal volume ratio, improving alveolar ventilation and oxygenation.[19]

There is a further need to understand the effect of specific breathing exercises in improving saturation and weaning from oxygen. Prolonged effect and change and maintenance of oxygenation with multiple sessions in the day were not studied and need to be explored further.

Conclusion

Both side-lying, prone positioning and breathing exercise can make a significant difference in the saturation of oxygen of non-intubated patients on FM, NRBM, or NIV. This study showed that a duration of 30 min did adequately improve saturation.

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Conflicts of interest

There are no conflicts of interest.

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