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**Research Article**

# A comparative study of supine lying, side lying and prone positioning on oxygen saturation, in mechanically ventilated patients, in acute respiratory failure

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## ABSTRACT

**Background:** Body positioning refers to optimize $O_2$ transport by manipulating effect of gravity on cardiopulmonary and cardiovascular function. Positioning should be an integral part of respiratory care, especially when prophylaxis is aim. Turning patient supine to lateral to prone to lateral, at least hourly makes a difference between living and dying for intensive care patient. Positioning reduces atelectasis and improves gas exchange.
**Methods:** Total 33 subjects aged between 15-73 years, 21 male and 12 female patients were selected for study from ICU, Neurological trauma unit Pune. *Inclusion criteria*: All subjects with respiratory failure due to different pathologies like ARDS, Pulmonary edema, pneumonia, tuberculosis, collection of fluid in pleural cavity with underlying lung collapse. *Exclusion criteria*: Unstable cardiac conditions, unstable fractures, unstable hemodynamic, recently operated cardiac subjects. The patients were kept in supine position, lateral and prone and vitals like BP, HR, RR and oxygen saturation with help of pulse oximeter noted just before position. Thorough ET or tracheostomy suction was done. Before turning patient if any intercostal drain present was clamped.
**Results:** Paired t-test was used. p values for prone and bilateral side lying positions was $< 0.05$ showing its significance for above mentioned 3-positions. p value for supine was not $< 0.05$ showing its non-significance.
**Conclusion:** The study concluded that oxygen saturation improves in prone lying and side lying position as compared to supine lying. But this improvement is quiet significant in prone position as compared to side lying.

**Keywords:** Acute respiratory failure, Atelectasis, Oxygen saturation, ARDS

## INTRODUCTION

Body positioning refers to optimize $O_2$ transport, primarily by manipulating the effect of gravity, on cardiopulmonary and cardiovascular function.[1] Changing a patient's posture may not seem a dramatic technique, but this simple action often prevents recourse to more time consuming or tiring techniques. Positioning should be an integral part of all respiratory care, especially when prophylaxis is the aim.[2] There may be a fine irony in the observation that our advanced knowledge and technology by themselves can't save the patient. Instead something as simple as turning the patient supine to lateral to prone to lateral, at least hourly makes a difference between living and dying for intensive care patient. Positioning is the main treatment for patients in intensive care.[3] By preventing the abdominal contents encroaching on lung volumes positioning restores ventilation to dependent lung regions more effectively than PEEP or large tidal volumes.[4] For ventilated patients the main problem is loss of lung volume, secretions usually being of little note. Positioning is the first approach. Positioning reduces atelectasis and improves gas exchange.[5] Barotraumas is less likely to occur in the dependent lung.[6] Many breathless patients automatically assume a posture that eases their breathing. But in ICU its physiotherapist's skill to opt for the best position depending on the lung pathology and assume the most beneficial outcome in favour of patient. Supine is the least helpful position for lung function.[7] For ventilated patients the lateral position increases FRC and enhances gas exchange compared with supine.[8] The prone position is useful for some severely hypoxic patients.[9] A more dramatic improvement in $SaO_2$ may be found by gently turning the patient into prone. This can reverse atelectasis in non-dependent lower lobes, which improves overall gas exchange because there is more space in lungs posteriorly due to chest triangular cross section and space taken up by heart anteriorly. Lung expansion is also more uniform in prone than in supine because the heart is supported by sternum and there is less parenchymal distortion.[10] By opening previously deflated lung, oxygenation may improve to such an extent that PEEP and $FiO_2$ can be reduced.[11] The benefits are reversed on returning patient to supine and many patients are best left in prone for extended periods. Patients who are confined to bed should spend a proportion of time on their side lying well forwards so that their diaphragm is free from abdominal pressure. Compared to supine this position not only increases lung volume, but also improves gas exchange and reduces work of breathing. Airflow resistance is lower in side lying compared to supine. Optimizing $O_2$ transport is goal of positioning and mobilization.[12] Adaptation or training sensitive zones defines the upper and lower limits of the various indices of oxygen transport needed to elicit optimal adaptation of the steps in oxygen transport pathway. This zone is based on an analysis of the factors that contribute to cardiopulmonary dysfunction and thus is specific for each patient. Manipulating body position, however alters both inter regional and intraregional determinants of ventilation and perfusion and their matching. Variant of the prone position, prone abdomen free has shown additional benefits over prone abdomen restricted so that movement of abdomen is unencumbered by bed.[13]

When beneficial positions are assumed too long however hydrostatic, gravitational and compressional forces acting on heart, blood volume, lymphatic system, lungs and chest wall including the diaphragm will eventually compromise $O_2$ transport and any beneficial effect is offset**.** Frequent changes in body position and avoidance of prolonged periods in any single position will minimize risk of diminishing returns, which are inevitable**.** The time course differs according to the pathology type, severity and other factors. The duration a patient assumes a body position should be primarily response dependent rather than time dependent.

## METHODS

Study design was experimental with purposive sampling. Total 33 subjects between the age group 15-73 years, 20 male and 11 female patients selected for study purpose from Intensive care unit, Neurological trauma unit, Pune. All subjects with the respiratory failure due to different pathologies like ARDS, Pulmonary edema, pneumonia, tuberculosis, collection of fluid in pleural cavity with underlying lung collapse were included. Patients having unstable cardiac conditions, unstable fractures, unstable hemodynamic and recently operated cardiac subjects were excluded from the study. Patients were given supine, side lying and prone position each for 1 hour. Oxygen saturation noted at the start of 1 hour and the end of 1 hour. The patients were kept in supine position and all vitals like BP, HR, RR with the help of central monitor and oxygen saturation with the help of pulse oximeter noted just before the position and correlated with ABG report. Ventilator settings were also noted pre and post position. The conscious patients were briefly explained about the procedure. The next stage included turning patient in lateral position. Before turning suctioning was done. The patients turned on either side depending on the pathology of lung which side was more affected. In unilateral lung pathology lung involved i.e. affected lung was positioned uppermost. Thorough ET or tracheostomy suction was done. Before turning patient if any intercostal drain present was clamped. Then patient turned to the lateral (either) side as one log. Care was taken with head injury patients and those who had cervical collar for stabilization in supine. A pillow was placed between two legs and upper knee flexed. The upper limbs especially on affected lung side were placed away from body with slightly abducted shoulders. This prevented any mechanical obstruction to expansion of the affected lung. Jejunostomy or nasogastric feed stopped 2 hours before position. The position of endotracheal tube or tracheostomy tube was checked. All other invasive lines were checked. The ICD which was clamped before position, was released after positioning. Abdomen was kept free for proper movement of diaphragm. The head was turned to lateral side to provide comfort to the patient and also to avoid kinking of ET or TT tube. The head position was preferably kept to lateral side of ventilator. This reduced any pulling of ventilator tubing and thus minimized any chances of accidental extubation. Materials used were bed, pillow, towel roll, monitor, suction apparatus B P apparatus, pulse oximeter.

## RESULTS

For the study purpose total 33 patients were selected, 21 male and 12 female. Out of 33 patients, prone position for 76 years male patient had to be discarded after 20 minutes because of tachycardia of 145, ECG changes and hypo tension of BP<60 mm Hg. Another 55 years female patient had to be excluded from study because of discontinuation of prone position due to hemodynamic instability and severe tachycardia, HR>175 after 35 minutes. At the end of study total 31 patients were finalized and statistical analysis of SPO2 pre and post positioning was calculated. Paired t test was used. p values for prone and bilateral side lying positions was <0.05 showing its significance for above mentioned 3-positions.p value for supine was not < 0.05 showing its non-significance. Value for prone position was 4.83, for supine 0.48, for left lateral 1.96 and for right lateral it was 1.9. This value was highest for prone position suggesting maximum beneficial effects of this position.

**Table 1: Statistical analysis in various positions.**

| | MEAN BF 1HR | MEAN AFT 1HR | SD BF 1HR | SD AFT 1HR | T Value | P Value |
|---|---|---|---|---|---|---|
| Prone | 91.51613 | 96.35484 | 5.58 | 7.34 | 4.68 | Significant |
| Rt Lateral | 91.83871 | 93.74194 | 5.38 | 5.59 | 6.33 | Significant |
| Lt Lateral | 92.35484 | 94.32258 | 5.77 | 6.36 | 6.12 | Significant |
| Supine | 91.54839 | 92.03226 | 5.75 | 7.05 | 1 | Non Significant |

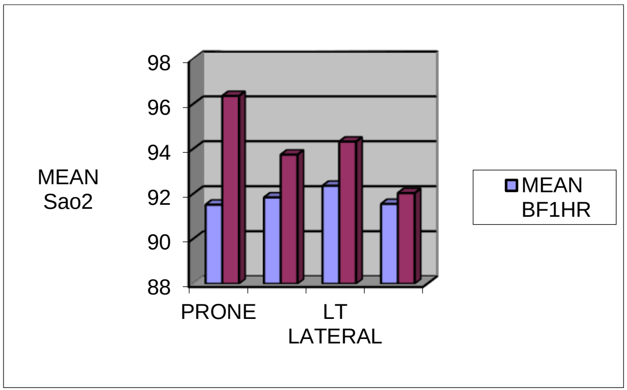


**Figure 1: Comparison of various positions.**

## DISCUSSION

The current study has been focused to observe the effects of supine, side lying and prone positions on oxygen saturation in mechanically ventilated patients with respiratory failure, to see that prone position is most effective to improve the oxygen saturation and to observe the effect of improved saturation on mortality rate. Our findings that prone and side lying improves oxygenation and with prone, improvement is maximum confirm the preliminary data. Respiratory system which consists of lungs, chest wall, performs the vital function of ventilation and gas exchange.[14] Respiratory failure may be defined as a significant impairment in these functions and is recognized by the presence of arterial hypoxia and/or hypercarbia. It is type 1 respiratory failure and type 2 respiratory failure. In type1 respiratory failure PO2 decreases, $P_H$ decreaes, PCO2 might be normal. In type 2 respiratory failure PCO2 increases,Po2 might be normal or decreased. Drugs, metabolic factors, primary CNS events affects the central respiratory drive. Obstuctive lung disease, restrictive disease imposes excessive respiratory load and inadequate drive together cause ventilatory failure.[15] The respiratory failure can be impended due to malnutrition, neuromuscular disease, and hyperinflation conditions. The oxygen needed for ventilation is transported from lungs to peripheral tissues by hemoglobin that is densely packed in our RBCs. A critical situation develops when the O2 demand exceeds $O_2$ supply. The phenomenon of $O_2$ delivery, dependence of $O_2$ consumption occurs when a $O_2$ transport system is unable to supply sufficient $O_2$ to meet basal $O_2$ demands. The greater the delivery in relation to consumption, the greater the safety margin is.[16,17] This is so called pathological dependence of $O_2$ consumption on $O_2$ delivery occurs when the cells are inadequately extracting and using $O_2$ even in presence of supernormal $O_2$ delivery levels. This phenomenon is observed in respiratory failure.[13] It is seen that positioning is very important adjunct to $O_2$ therapy because Hb can't be more than fully saturated, so that solely $O_2$ therapy is unhelpful for patients, with a high $PO_2$ and hyperventilation of functioning alveoli can't supersaturate arterial blood to compensate for hypoxemia, resulting from poorly functioning alveoli.[2] In the present study, statistical increase was seen in $SaO_2$ more in prone position as compared to supine and side lying. The prone position increases arterial oxygen tension, tidal volume and lung compliance. Improvement in $SaO_2$ in prone lying could be because of improved lung compliance, diaphragmatic excursion and FRC and reduced airway closure.[13] Margareta Mure in 1997 studied 13 patients suffering from severe acute lung insufficiency and came to conclusion which supports the present study. She concluded that prone position increases lung compliance and lung volume not only due to a changed geometry of rib cage but other mechanical factors such as bronchial drainage of secretions and the movement of extra vascular lung fluid, according to gravity may be possible contributing factors. Once the secretions in the dependent lung regions are drained due to positioning, the oxygen saturation improves.[18] Mutoh et al in 1992 stated that volume overload increases the P (A-a) $O_2$ and the pleural pressure in the dependent lung region.[19] Gravitational gradient of pleural pressure is less in the prone compared with the supine.

Prone position generates a transpulmonary pressure in dorsal lung regions, in regions where atelectasis, shunt and ventilation/perfusion heterogeneity are most severe.[11] In the present study, the patients with head injury were also given prone position. These patients showed significant improvement in $SaO_2$ without any deleterious effects. This shows that prone position is possible under intra cranial pressure monitoring in selected cases of severe head injury.[20] Prone position increases ICP by increasing cerebral venous pressure. Brain tissue O2 tension seems to be a predictive factor for survival and better outcome. The present study shows improved Sao2 due to prone position statistically compared to lateral and supine position. It is supported by the findings of Pelosi et al 1998 that there is increase in $PO_2/FIO_2$ more than 20.[21] The restricted movement of more freely movable sternal part of the rib cage along with decreased compression of the lungs by the heart and decreased vertical plural gradient allows preferential distribution of tidal volume to the dorsal regions of the lung. There is reduction in mean positive airway pressure. The mechanism of the positive findings for the prone position may be attributed to the fact that in prone, the height of the lung is lower whereas the width is greater and because of downward displacement of diaphragm. The improvement in oxygenation related to prone position is associated with an improvement in ventilation/perfusion matching that is attributed to shifting of blood away from shunt region.[22] The air goes to the parts of the lungs that are less ventilated because of the lung pathology and the blood flow is diverted to less perfused lung parts thereby correcting the ventilation/perfusion mismatch. The unique findings in the present study shows that the ventilation becomes more uniform with PEEP in prone with redistribution from dependent to non-dependent lung region and gravitational component of ventilation.[23] The beneficial outcome with increase $PO_2/FIO_2$ response to prone position might be because of decrease in $PCO_2$.[24] In the present study 2 pregnant patients with ARDS were given abdomen free prone position with improvement in $SaO_2$ after 1 hour.[25] This improves oxygen saturation because there is no upward push to the diaphragm by encroaching abdominal organs and so the diaphragm is more free to move there by facilitating basal lung expansion. The improvement in $SaO_2$ remains persistent even if the patient is turned from prone to supine position and is supported by various studies.[26] Above positive findings are confirmed by various authors in their studies radiologically.[27] Gattinoni *et al*., in 1991 found a more homogenous regional inflation assessed by lung density by CT in prone position than in supine position in patients with ARDS. Owens et al describes a statistical significance in overall percentage abnormality on CT scan. The amounts of infiltrates are reduced on CT scan.[28] In present study 18 out of 31 patients died not only because of respiratory failure but due to either sepsis or multisystem organ failure. This shows that prone position doesn't affect mortality because most patients die of multiorgan failure and septicemia had probably already affected physiological functioning of vital organs other than lungs.[29,30] This statement is supported by Dries in 1998 and Jorge *et al.,* in 2002. Present study shows statistical insignificance for supine position.

In supine position excess secretions tend to pool on the dependent side of the airway. The presence of secretions ultimately hampers air entry to that part of the lung leading either to no change in saturation or sometimes might reduce the saturation in supine position. Thus upper side may dry out, exposing the patient to infection and obstruction. But in ventilated patients temporary $PO_2$ can rise if associated with the sigh with respective increase of end expiratory lung volume, which is often practiced in ICU.[31] In the present study statistical analysis shows additive benefit of side lying position over supine position. Thus it is confirmed that compared with supine position, side lying is more physiological and thus a more justifiable position in terms of its benefits. The side lying position accentuates AP expansion at the expense of transverse expansion of the dependent chest wall. In this position hemi diaphragm is displaced cephalad because of the compression of the abdominal viscera beneath it. This results in greater excursion during ventilation of that lung and to gas exchange as a whole. Benefits of this position are that compliance is increased and resistance is reduced. But the disadvantage found in present study is decreased air entry on dependent side on auscultation. This is due to reduced lung compliance on that side due to mechanical obstruction to chest wall. Also there is increased diastolic ventricular pressure on that side secondary to compression of the viscera beneath the diaphragm. But side lying can be used to enhance the efficiency of $O_2$ transport. This fact is supported by various studies. In the present study maximum patients got right side lung affection and they showed $SaO_2$ improvement in left lateral than in right lateral. Arterio to venous blood $O_2$ content difference, $O_2$ consumption and utilization are significantly lower than in supine position. $PO_2$ increases when the sick lung is up and $PO_2$ decreases when sick lung is down.[7] This may be because positional changes have a gravitational effect on the distribution of pulmonary blood flow. Rivara studied 8 patients with unilateral interstitial pattern improvement in oxygenation which occurred when good lung was down is associated with changes in pattern of V/Q distribution, decrease in right to left intra pulmonary shunt.[31,32] When lung pathology is bilateral, arterial blood gases are improved, when patients lie on the right side compared with the left.[13] This can be explained by the greater size of the right lung and reduced compression of the height on lung in this position compared with left lying. Thus increased regional ventilation under the influence of gravity with an overall improvement in ventilation/ perfusion ratio appears to be main mechanism of position induced improvement in oxygenation.[33] Strong evidence exists, for positioning with the affected lung superior in acute respiratory failure, due to unilateral lung disease. Hemodynamic risks however has been shown to be associated with prone and side lying position.

The result of the present study shows that the improvement of gas exchange can be accounted for by the rearrangement of ventilation/perfusion relationships. This management can avoid the need for differential lung ventilation. The variability between the values of Sao2 pre and post positional bilateral side lying positions on the present study can be explained by non homogeneity of pulmonary disease in patients with respiratory failure.

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