

# The effect of positional changes on oxygenation in patients with head injury in the intensive care unit

Jigar Nayankumar Mehta<sup>1</sup>, Lata D. Parmar<sup>2</sup>

<sup>1</sup>Department of Physiotherapy, K M Patel Institute of Physiotherapy, Shree Krishna Hospital Karamsad, <sup>2</sup>Department of Physiotherapy, Sumandeep Vidyapeeth, Vadodara, Gujarat, India

**Background:** Following head injury, cardiopulmonary functions are impaired and this disturbs the oxygenation transport pathway. Expanding cardiopulmonary physical therapy to encompass the oxygen transport system as a whole has implication for treatment as well as assessment and treatment outcome. Therefore, the aim of the study is to assess the oxygenation level in head injury patients with relation to body positioning in the intensive care unit (ICU). **Methodology:** Thirty consecutive patients with head injury with hemodynamically stable were included from the surgical ICU, ages ranging from 15 to 50 years. Noninvasive vital parameters (oxygen saturation [SpO<sub>2</sub>], pulse rate [PR], respiratory rate [RR], and blood pressure [BP]) were observed and recorded in different body positions at regular intervals of 5 min for 15 min in each position. **Results:** There was increment in SpO<sub>2</sub> value in all positions from 0 min to end of 15 min in supine (98.63 ± 0.36–98.73 ± 0.30), right-side lying (98.77 ± 0.30–98.93 ± 0.20), left-side lying (98.73 ± 0.29–99.03 ± 0.24), and recline sitting (30°–70°) (99.03 ± 0.24–99.50 ± 0.22). However, there was statistically significant increment in recline sitting (30°–70°) compared to other positions ( $P = 0.036$ ) while other parameters (PR, RR, and BP) were getting stabilized at lower values at end of 15 min in every positions tested. **Conclusion:** We conclude that upright position bring about significant increase in arterial SpO<sub>2</sub> compared to any other positions. Other vital parameters were seen to stabilize at lower values at the end of 15 min in every position tested.

**Keywords:** Body position, head injury, hemodynamic parameters, oxygenation

## Introduction

Head injuries are a major cause of morbidity and mortality in the community. Majority of the head injuries are consequences of road traffic accidents (RTAs), falls, assaults, or injuries, occurring either in the workplace, during sport, or at home.<sup>[1]</sup>

External forces hitting the head hard enough to cause brain movement cause traumatic brain injury (TBI). Injuries include those with skull fracture and those without skull fracture

(closed head injuries). Acceleration, deceleration, rotational forces, and penetrating objects act to cause tissue laceration, compression, tension, shearing, or a combination, resulting in primary injury.<sup>[2]</sup>

Hypoxemia is observed in many patients with injury to the central nervous system (Demling, 1980). This may reflect primary damage to the cardiopulmonary centers of the brain due to increased intracranial pressure (ICP), cerebral hypoxia or ischemia, intracranial hemorrhage, and secondary effects of associated trauma. Further, following head injury, cardiopulmonary functions are impaired and this disturbs the oxygenation transport pathway. Expanding cardiopulmonary physical therapy to encompass the oxygen transport system as a whole has implication for treatment as well as assessment and

**Address for correspondence:** Dr. Jigar Nayankumar Mehta, K M Patel Institute of Physiotherapy, H. M. Patel Centre for Medical Care and Education, Shree Krishna Hospital, Gokal Nagar, Karamsad - 388 325, Gujarat, India.  
E-mail: jigarjm@charutarhealth.org

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treatment outcome. Physiologic and scientific literature till date supports the clinical efficacy of two noninvasive interventions, namely positioning and mobilization, which have both direct and profound effects on multiple steps of oxygen transport pathway.<sup>[3,4]</sup>

Turning and positioning of critically ill patients in the intensive care unit (ICU) are well-accepted activities, with the primary purpose being to relieve pressure, improve patients comfort, and aid pulmonary secretion. However, body positioning of critically ill patients may have a profound effect on arterial oxygenation, which is reflected by the oxygen saturation (SpO<sub>2</sub>) level in blood. The literature supports the benefits of frequent body positions changes, particularly for a patient who is relatively immobile, unalert, severely debilitated, obtunded, breathing at low lung volumes, obese, aged or very young, or has lost the sigh mechanism. The practice of routinely turning patients every 2 h continuously is an accepted standard of care.<sup>[5]</sup> Appropriate positioning of critically ill patient can significantly improve gas exchange. This may result in shorter stay in critical care unit and improved outcome for the critically ill patients and may avert the admission of some patient to the critical care unit (Moore, 2002).<sup>[6]</sup>

In 2010, Ledwith *et al.* studied on the effect of body position on cerebral oxygenation and physiological parameters in acute neurological condition patients and mentioned that nurses must consider potential effect of turning, evaluate changes with positioning on the basis of monitoring feedback from multimodality devices, and make independent clinical judgments about optimal positions to maintain or improve cerebral oxygenation.<sup>[7,8]</sup>

There are several studies which correlate oxygenation level with body positioning in cases of lung pathological conditions, pleural effusion, etc.<sup>[9]</sup> However, few studies are available which correlate oxygenation level with body positioning in patients with head injury.

The aim of the study therefore was to assess the oxygenation level in head injury patients with relation to body positioning in the ICU. The objective of the study to observe and monitor the changes in SpO<sub>2</sub>, pulse rate (PR), respiratory rate (RR), and blood pressure (BP) in various body positions via supine, side lying, and reclined position (30°–70°) and in transition from one position to other.

## Methodology

The study design was one-time observational cross-sectional design where 30 consecutive patients with head injury were recruited from the surgical ICU (SICU) of a tertiary care hospital.

Inclusion criteria for the study were head injury patients between 15 and 50 years of age with or without supplement oxygen support, either operated or nonoperated, hemodynamically stable, and both gender included.

Exclusion criteria of the study were fractures of the pelvis, spine, shoulder girdle, ribs, or long bones, spinal cord injury, hemodynamically unstable patient (such as severely hypertensive, acute myocardial infarction, Acute respiratory distress syndrome, and unstable angina), any past history of cardiac or thoracic surgery (such as coronary artery bypass graft surgery and percutaneous transluminal coronary angioplasty), any patients complaining of pain or discomfort while positioning or if the patient becomes hemodynamically unstable during changing of position or any position.

Instruments were used in the study as follows;

1. Digital multipara monitoring system along with pulse oximeter (IntelliVue Patient Monitor, MP20/30, Philips)
2. Sphygmomanometer, stethoscope, wristwatch, pillows, adjustable fowler's bed.

The study proposal was prepared and the Human Research Ethical Committee of institute granted approval to the proposed protocol to conduct the study. Thirty consecutive subjects who were referred for physiotherapy were taken from SICU after they satisfied the inclusion criteria. Of 30 subjects, 27 were males and 3 were females.

The medical records were reviewed and required data were recorded from medical file and examined as applicable. Informed consent was obtained from every subject/relative after explaining the details of various noninvasive tests to be conducted. Following the above initial assessment, after assuring proper resting status of the patient, various positions were given and the vital parameters were assessed.

In ICU, head injury patients were invariably on monitor device (IntelliVue Patient Monitor, MP20/30, Philips) which was used for monitoring the vital parameters of the patients, and these monitor was used in the study as well. It consist of ECG leads which are attached to the chest, Pulse oximeter probe attached to the figure or the toe and a noninvasive blood pressure cuff tied on the opposite arm to the pulse oxymeter probe. These attachments were connected with the monitor via a cable which continuously displays the vital parameters such as ECG rhythm, arterial SpO<sub>2</sub> value with its waveform, BP and RR. These parameters were utilized as a data for the study.

The four positions chosen for this study were supine lying, left lateral, right lateral, and reclined sitting (30°–70°). In this study, modified lateral positions (45° left- and right-side lying position) had to be used for many patients with craniotomy and other problems (such as fracture clavicle), and therefore, vital parameters were recorded in that position only.

Each position was maintained for 15 min, and the initial vital parameters in that particular position and then at the end of every 5 min interval were observed and recorded. This study was single time study for one patient in 1 day only. No particular sequence was followed for changes in position, and no therapeutic maneuver was performed during the period of study.

It was decided that if during changing the position or maintaining particular position if patient felt discomfort or was hemodynamically found unstable, then the patient would be returned to the comfortable resting position and would be excluded from the study. The doctor in-charge would be summoned also informed for the same for immediate medical attention.

In this study, outcome measures were vital parameters such as SpO<sub>2</sub>, PR, RR, and BP, which were recorded from the digital monitor as said before.

### Results

The data were fed into a computer in Microsoft Excel Sheet. For statistical analysis, the SPSS software was used. Analysis started with descriptive statistics (frequency table, mean, standard deviation, and standard error); *t*-test was used to compare mean values of variables between two positions. The statistical significance level for each comparison was considered at 5% level (*P* < 0.05).

In this study, 30 participants with head injury were recruited, of which 27 (90.0%) were males and 3 (10.0%) were females, with a mean age being 35 years (range, 15–50 years). RTA was the major contributing cause of head injury in 63.3% of population (19 participants). Other causes such as assault injuries and falls account for about 16.6% (5 participants) and 20.1% (6 participants), respectively [Figure 1].

The data were analyzed to compare the difference of vital parameters in a particular position at 0 and 15 min [Table 1]. It was found that there was statistically significant difference in the means of RR and PR between 0 and 15 min in supine lying position; both the parameters were found to be decreased at the end of 15 min. With regard to lateral decubitus, there was a statistically significant difference seen in all the parameters between 0 and 15 min. All the parameters statistically significant except SpO<sub>2</sub> decreased at the end of 15 min in both left- and right-side lying positions. Mean SpO<sub>2</sub> showed increment in

both the positions at the end of 15 min. However, this was not statistically significant [Table 1].

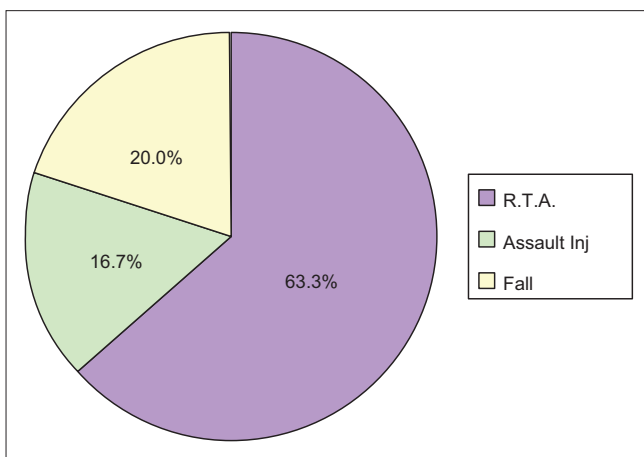
Comparison of vital parameters at 0 and 15 min in recline sitting (30°–70°) showed statistical significant difference in means of SpO<sub>2</sub>, PR, and RR. SpO<sub>2</sub> showed significant increase in recline sitting (30°–70°) while RR and PR stabilize at lower value after 15 min [Table 1]. However, there was statistically significant increment in SpO<sub>2</sub> in recline sitting (30°–70°) compared to other positions [Figure 2].

There was a comparison of mean difference of vital parameters at 0 and 15 min between two positions; it was found that systolic blood

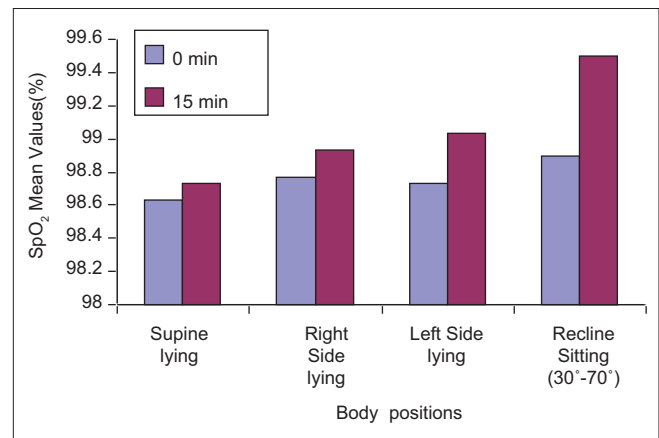
**Table 1: Comparison of mean values of vital parameters (arterial oxygen saturation, pulse rate, respiratory rate, blood pressure) in various body position at 0 and 15 min**

Positions	Vital	Mean±SE		t	P
		0 min	15 min		
		Supine lying	SpO <sub>2</sub>		
	PR	79.20±2.65	77.13±2.90	2.624	0.014*
	RR	18.00±0.46	17.03±0.42	2.926	0.007*
	SBP	122.60±2.13	122.13±2.38	0.537	0.595
	DBP	77.80±1.74	76.87±1.89	1.600	0.120
Right-side lying	SpO <sub>2</sub>	98.77±0.30	98.93±0.20	-0.776	0.444
	PR	80.33±2.66	77.80±2.64	3.285	0.030*
	RR	18.23±0.51	17.14±0.46	2.679	0.012*
	SBP	123.80±2.55	120.27±2.24	3.614	0.001*
	DBP	78.93±2.32	76.63±2.01	2.369	0.025*
Left-side lying	SpO <sub>2</sub>	98.73±0.29	99.03±0.24	-1.159	0.256
	PR	80.50±2.92	77.27±2.68	3.170	0.004*
	RR	18.37±0.52	17.40±0.45	3.293	0.003*
	SBP	123.20±0.43	119.20±2.41	3.516	0.001*
	DBP	79.40±1.87	75.77±2.02	2.688	0.012*
Reclined sitting	SpO <sub>2</sub>	98.90±0.38	99.50±0.22	-2.193	0.036*
	PR	79.83±2.42	76.50±2.59	4.621	0.000*
	RR	18.20±0.50	17.37±0.50	2.934	0.006*
	SBP	122.73±2.14	121.37±2.18	1.465	0.154
	DBP	78.00±1.64	76.93±1.78	1.152	0.259

\*SpO<sub>2</sub>: Arterial oxygen saturation; PR: Pulse rate; RR: Respiratory rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; SE: Standard error



**Figure 1: Causes of head injury**



**Figure 2: Comparisons of mean oxygen saturation in various body positions at 0 and 15 min**

pressure (SBP) showed statistically significant change in right-side lying when compared to supine lying. The SBP decreased in the right-side lying as compared to supine lying. On comparison of supine lying with left-side lying, statistically significant change was seen also in diastolic blood pressure (DBP) along with SBP. Both SBP and DBP show decrease in left-side lying position [Table 2].

There was no any statistical significance seen while comparison of two positions at 0 and 15 min of vital parameters when considering supine lying and recline sitting (30°–70°), right- and left-side lying, and right-side lying and left-side lying with recline sitting (30°–70°) [Table 2].

### Discussion

The amount of oxygen in a medium is known as oxygenation. Medium could be water or body tissue. Hence, in blood, oxygen could be taken to be synonymous with saturation, which describes the degree to which the oxygen-carrying capacity of hemoglobin

is utilized, normally 98%–100%.<sup>[10]</sup> When considering adequacy of oxygen delivery to the tissues, the factors need to be taken into account are hemoglobin concentration, cardiac output, and oxygenation.<sup>[5]</sup>

Oxygenation is commonly affected in patients with head injury; in cardiopulmonary physical therapy, one way of improving oxygen delivery is through positioning of the patients to optimize the ventilation–perfusion ratio. Body positioning of critically ill patients/TBI patients may have a profound effect on arterial oxygenation which is reflected by SpO<sub>2</sub> level in the blood. Body position has its potent and direct effect on oxygen transport; therefore, therapeutic body positioning is a primary, noninvasive, and single most important objective of physical therapy intervention that can augment arterial oxygenation so that invasive, mechanical, and pharmacological forms of respiratory support can be postponed, reduced, or avoided.<sup>[5]</sup>

Systemic monitoring of oxygen (PaO<sub>2</sub>, SaO<sub>2</sub>, and SpO<sub>2</sub>) is recommended in patients who require neurocritical care.<sup>[11]</sup> In the present study, SpO<sub>2</sub> (arterial SpO<sub>2</sub>) has been used as an outcome measure to assess the oxygenation level in the body.<sup>[12]</sup> Although artery bypass graft analysis is the gold standard for assessing oxygenation very accurately, yet it is practically not feasible to undergo arterial blood sampling (an invasive method) with every change in position. Therefore, SpO<sub>2</sub> was being used. It is believed that the benefits of this noninvasive, continuous saturation monitoring technique outweigh the information obtained by intermittent measurements of arterial blood gases.<sup>[13,14]</sup> It is important to note that there is a relationship between the partial pressure of oxygen and the percentage saturation of hemoglobin with oxygen as it can be explained by oxygen-hemoglobin dissociation curve.<sup>[15]</sup>

Before discussing the result of the study, it is worth noting that the review of literature is inadequate or limited with regard to guidelines on how to position to improve oxygenation. Assessment is needed to establish optimal positions for patients, and then ongoing monitoring is essential to determine their effects and when to change a patient’s position. Physiological effects of body positioning are mediated by gravity and compression.<sup>[16]</sup> Therefore, in the present study, the effect of positional changes on oxygenation in patients with head injury in ICU was undertaken. This was assessed by monitoring the vital parameters (SpO<sub>2</sub>, PR, RR, and BP) in head injury patients during various body positions.

To begin with the saturation, SpO<sub>2</sub> value was maintained at acceptable level (hemodynamically stable) in each position, and it showed minimal increase at the end of 15 min in the following sequence; supine, right-side, left-side, and recline sitting. However, the statistically significant improvement was noted in SpO<sub>2</sub> only in reclined sitting (30°–70°).

This is an agreement with a number of studies reported that SpO<sub>2</sub> level is significantly greater in more upright positions.<sup>[5,6,17,18]</sup>

**Table 2: Comparison of mean values of vital parameters (arterial oxygen saturation, heart rate, respiratory rate, blood pressure) in various body positions at 0 and 15 min**

Positions	Vital	Mean±SE		t	P
		0 min	15 min		
Supine lying versus right-side lying	SpO <sub>2</sub>	0.10±0.24	0.17±0.21	-0.209	0.835
	PR	-2.07±0.79	-2.53±0.77	0.423	0.674
	RR	-0.97±0.33	-0.83±0.31	-0.294	0.770
	SBP	-0.47±0.87	-3.53±0.98	2.344	0.023*
	DBP	-0.93±0.58	-2.30±0.97	1.207	0.232
Supine lying versus left-side lying	SpO <sub>2</sub>	0.10±0.24	0.30±0.26	-0.570	0.571
	PR	-2.07±0.79	-3.33±0.72	0.905	0.369
	RR	-0.97±0.33	-0.97±0.29	0.000	1.000
	SBP	-0.47±0.87	-4.00±1.14	2.468	0.017*
	DBP	-0.93±0.58	-3.63±1.35	1.834	0.072*
Supine lying versus reclined sitting	SpO <sub>2</sub>	0.10±0.24	0.53±0.24	-1.277	0.207
	PR	-2.07±0.79	-3.33±0.72	1.186	0.240
	RR	-0.97±0.33	-0.83±2.28	-0.306	0.761
	SBP	-0.47±0.87	-1.37±0.93	0.706	0.483
	DBP	-0.93±0.58	-1.07±0.93	0.122	0.903
Right-side lying versus left-side lying	SpO <sub>2</sub>	0.17±0.21	0.30±0.26	-0.396	0.693
	PR	-2.53±0.77	-3.23±1.02	0.547	0.586
	RR	-0.83±0.31	-0.97±0.29	0.312	0.756
	SBP	-3.53±0.98	-4.00±1.14	0.311	0.757
	DBP	-2.30±0.90	-3.63±1.35	0.801	0.426
Right-side lying versus reclined sitting	SpO <sub>2</sub>	0.17±0.21	0.53±0.24	-1.130	0.263
	PR	-2.53±0.77	-3.33±0.72	0.758	0.452
	RR	-0.83±0.31	-0.83±0.28	0.000	1.000
	SBP	-3.53±0.98	-1.37±0.93	1.603	0.114
	DBP	-2.30±0.97	-1.07±0.93	-0.910	0.362
Left-side lying versus reclined sitting	SpO <sub>2</sub>	0.30±0.26	0.53±0.24	-0.657	0.514
	PR	-3.24±1.02	-3.33±0.72	0.080	0.936
	RR	-0.97±0.29	-0.83±0.28	-0.236	0.745
	SBP	-4.00±1.14	-1.37±0.93	-1.790	0.079
	DBP	-3.63±1.35	-1.07±0.93	0.681	0.499

\*SpO<sub>2</sub>: Arterial oxygen saturation; PR: Pulse rate; RR: Respiratory rate; SBP: Systolic blood pressure; SE: Standard error; DBP: Diastolic blood pressure

The probable reason could be that the more upright positions are better in terms of improved ventilatory mechanism and ventilation–perfusion matching.<sup>[5,19]</sup> The other positions did not show any significant improvement; the probable reason could be that the pulse oximeter is relatively insensitive at the upper end of the oxygen dissociation curve.<sup>[20]</sup>

In this study, it was observed that a decrement in PR, RR, SBP, and DBP occurred in all four positions at the end of 15 min. Mean PR significantly decreased in each of four positions at the end of 15 min, the amount of decrement was in the following order: supine, recline sitting (30°–70°), right-side, and left-side lying. On comparison of any two positions, no statistically significant difference was found in mean PR between 0 and 15 min. Similar results were found in patients with pleural effusion by Neagley and Zwillich (1985).<sup>[9]</sup> The probable reason could be that 1–2 min may be required to stabilize consequent cardiovascular adjustment during a shift of position and up to 5 min to complete the most of autonomic adjustment.<sup>[9]</sup>

A number of studies showed that in general, the head of patients bed should be elevated to a minimum of 30° or greater, as clinically tolerated, at all times to reduce aspiration of contaminated oropharyngeal secretions and subsequent development of ventilator-associated pneumonia and reduce patient mortality in ICU.<sup>[21]</sup> Specifically, in patients with closed head injury, it has been recommended by surgical and medical critical care, regional medical center that reclined up to 30° or greater at all times is preferable to reduce ICP and maintain cerebral perfusion pressure.<sup>[18,21]</sup> The ventilation–perfusion matching can be directly manipulated by patients positioning and warrants being considered as a treatment priority to improve respiratory gas exchange in patients with head injury who may be at risk for developing pulmonary complications.<sup>[22]</sup>

Such research may help elucidate further and refine the essential beneficial aspects of body positioning. The use of judicious positioning can also enhance the effectiveness of therapeutic exercise in patients with and without pulmonary dysfunction.<sup>[22]</sup>

In 2010, McNett and Gianakis had studied on nursing intervention for critically ill traumatic brain patients and provided evidence of the multifaceted role of the neuroscience ICU nurse caring for TBI patients and can be used in future research investigating the impact of nursing interventions on patient outcomes.<sup>[23]</sup>

Having undertaken this study, it has become evident that knowledge of body positioning and its effects on oxygenation is essential for physical therapist and specially trained nurses who care for critically ill patients in ICU.

## Conclusion

The present study concluded that significant increment in SpO<sub>2</sub> level was noted in recline sitting position at the end of 15 min. There is a dearth of the knowledge regarding the use of body

positioning on oxygenation in head injury patients. It is therefore important to direct action towards this adjunct therapy which can help physiotherapist to prevent further neurological deterioration due to hypoxia in these patients.

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## Conflicts of interest

There are no conflicts of interest.

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