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Effect of Positioning on Oxygenation and Hemodynamics among Patients on Mechanical Ventilation

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ABSTRACT

Context: The routine practice of positioning is a vital procedure in critical care units, especially when prophylaxis is the aim. For many years, nurses have recognized that positioning prevents skin breakdown, mobilizes secretions, and provides comfort without identifying the impact of different positioning strategies on pulmonary gas exchange and ventilator weaning outcomes.
Aim: The current study was conducted to assess the effect of positioning on oxygenation and hemodynamics among patients on mechanical ventilation.
Methods: This study was conducted in the medical intensive care unit at El-Demerdash hospital, affiliated to Ain-Shams University. A descriptive exploratory study design was utilized in this study. A purposive sample of 93 patients was recruited in the present study. A structured interview questionnaire and patient assessment record were employed to collect data related to this study.
Results: The results reveal that 39.8% of the studied patients' age was between 45-<65, 30.1% had chronic obstructive pulmonary disease. Oxygenation significantly decreases in the supine position at p 0.003 and increases in the semi-recumbent position at p 0.020. Heart rate is significantly increased in semi-recumbent position at $p<0.005$. Systolic and diastolic blood pressure significantly decreased in semi-recumbent positions at $p<0.010$ and $p=0.021$, respectively, at T30, T60, and T120.
***Conclusion*:** Regarding oxygenation and hemodynamics, the results of this study concluded that the best oxygenation was in semi-recumbent position T120. Regarding hemodynamics, heart rate is significantly increased in the left lateral and semi-recumbent positions. Systolic and diastolic blood pressure were significantly affected by positioning. The time of changing position should be reviewed to be compatible with the most effective position for mechanically ventilated patients considering the patient oxygenation and hemodynamic states.

Keywords: Positioning, oxygenation, hemodynamics, patient, mechanical ventilation

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1. Introduction

Turning and positioning 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, the body positioning of critically ill patients may have a profound effect on hemodynamics and arterial oxygenation, which is reflected by the oxygen saturation (SpO2) level in the blood *(Mehta & Parmar, 2017).*

The positioning of a patient in bed can directly affect respiratory function in mechanically ventilated patients. In addition to reducing the risk of developing pneumonia, some postural positions can increase the possibility of more homogeneous alveolar ventilation and possibly reduce the risk of lung injury caused by mechanical ventilation (MV) *(Martinez et al., 2015).*

The correct positioning of patients can affect the blood oxygen saturation level by increasing lung volume, reducing the heart rate, helping mucociliary clearance, and improving ventilation/perfusion (V/Q) matching. Optimal oxygenation depends on the V/Q matching. The V and Q differences from the apex to the lung base have previously been attributed to gravity and tend to disappear in the supine position *(Alan & Khorshid, 2021).*

Early and adequate hemodynamic stabilization of the critically ill affects outcomes *(Tanczes, 2014).* Changes in the body position of patients receiving mechanical ventilation in the intensive care unit are frequent. Contrary to healthy humans, little data has explored the physiological

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impact of position on respiratory mechanics of mechanically ventilated patients *(Mezidi & Guérin, 2018).*

Critical care nurses constitute front-line care providers for patients in the ICU. Hypoxemic respiratory compromise/failure is a primary reason patients require ICU admission and mechanical ventilation. Critical care nurses must possess advanced knowledge, skill, and judgment when caring for these patients to ensure that interventions aimed at optimizing oxygenation and hemodynamics are both effective and safe *(Barton et al., 2016).*

2. Significance of the study

Patient positioning is an independent nursing intervention and, although it is important in patients with cardiovascular, cardiopulmonary dysfunction, and oxygenation problems, there is insufficient evidence to suggest a particular position *(Alan & Khorshid, 2021).*

Therefore, the study aimed to assess the effect of positioning on oxygenation and hemodynamics among patients on mechanical ventilation. The study's objective is to observe and monitor the changes in SpO_2, heart rate, and blood pressure in various body positions through supine, right lateral, left lateral and semi-recumbent position at 30-45 degrees and in transition from one position to another. This research may help explain and revise the main beneficial aspects of body positioning in mechanically ventilated patients.

3. Aim of the study

The present study aimed to assess the effect of positioning on oxygenation and hemodynamics among patients on mechanical ventilation.

4. Subjects & Methods

4.1. Research Design

A descriptive exploratory study design was utilized in this study, which was directed to observe, describe, and explore aspects of situation, persons, organization, settings, or phenomena *(Hennink et al., 2020).*

4.2. Study setting

The study was conducted at medical intensive care units affiliated to Ain-Shams University. The medical intensive care unit is on the first floor, and it consists of two sections of sixteen beds for each one. There were fifteen mechanical ventilators in two units and had seven staff nurses for each unit and one head nurse every twelve hours, day or night shift. It serves a broad sector of patients for free.

4.3. Subjects

A purposive sample of (93) patients from the previously mentioned settings was selected using power analysis according to the number of patients admitted to medical ICU in 2018 *(Statistical records of Ain Shams University Hospitals, 2018*). The estimated sample size is 93 patients, at a confidence level of 95%, and the precision rate at 0.05 by using *Matthews et al. (2012)* equation since the total number of patients admitted to the medical ICU in 2018 in 122 patients.

$$\textbf{Sample size, n} = N * \frac{\frac{Z^2 * p * (1-p)}{e^2}}{[N - 1 + \frac{Z^2 * p * (1-p)}{e^2}]}$$

While:
- N = The population size.
- Z= Critical value of the normal distribution at the required confidence level.
- P = Sample proportion.
- e = Margin of error.

Inclusion criteria
- Adult male and female patients above the age of 18 years old.
- On a mechanical ventilator.
- Have confirmed acute or chronic respiratory failure diagnosis for at least 72 hours from admission to the medical intensive care unit.

Exclusion criteria
- Patients with cardiopulmonary, circulatory dysfunction, pulmonary edema, and respiratory instability.
- Patients with fractures of the pelvis, spine, shoulder girdle, ribs, long bones, spinal cord injury.
- Hemodynamically unstable patients (severely hypertensive, acute myocardial infarction, acute respiratory distress syndrome, and unstable angina).
- Any history of cardiac or thoracic surgery (coronary artery bypass graft surgery and percutaneous transluminal coronary angioplasty).

4.4. Tools of data collection

The researcher designed data collection tools after reviewing the related literature. Data were collected using the following two tools:

4.4.1. Structured Interviewing Questionnaire

It included two parts:

Part I included patients' demographic data like age, gender, marital status, occupation, weight, height (BMI), diagnosis, and past medical history.

Part II: Patient medical record. This part was included the data about mechanical ventilation parameters: VT, PEEP, FIO_2, I/E ratio, mode, respiratory rate, static compliance, resistive pressure, PaO_2/FIO_2 ratio, RR, and oxygen saturation (SPO_2).

4.4.2. Patient Assessment Record

This record consisted of two parts:

Part I recorded the data about delivering routine care of positioning, which included the placement of the patient on each position for two hours in the order (supine, right lateral, left lateral, and semi-recumbent position head and torso at the angle of 30-45degree); where:
- T0: At the beginning changing each position.
- T30: After half an hour of positioning.
- T60: After an hour of positioning.
- T120: After two hours of positioning.

Part II included hemodynamics during each position; it was included the heart rate and blood pressure.

References range

- The patients were evaluated according to the standard normal range of
- Heart rate: 60 – 100 beats per minute
- Blood pressure: 120/80-140/90 mmHg *(Aronow, 2017).*

4.5. Procedures

A letter was issued to the Ain Shams University Hospital director from the Dean of Faculty of Nursing, Ain Shams University, explaining the aim of the study to obtain permission and cooperation to conduct the study. Also, approval was obtained from nursing directors of the medical ICU of Ain Shams University Hospitals.

Ethical Considerations: The faculty ethical committee obtained the research approval before starting the study. In addition, oral approval was obtained from each participant or his /her next of kin prior to data collection. They were assured that anonymity and confidentiality would be guaranteed and the right to withdraw from the study at any time.

Before starting the data collection, a pilot study was carried out on 10% of the studied sample (10 patients) who met the inclusion criteria to test the study's feasibility, applicability, clarity, and efficiency of the study tools. There was no modification done on the study tools so that the patients who were included in the pilot study were included in the main study group.

Tool validity was ascertained by a jury of three experts (one professor and two assistant professors) in the critical care department, Ain Shams University. They reviewed the tools for clarity, relevance, comprehensiveness, and applicability.

The investigator started the study by introducing himself to the medical and nursing staff of ICU and giving clear background about the aim of the study and expectations. After taking official permission, the purpose and nature of the study were explained to the subjects or relatives prior to data collection.

The study sample was recruited according to the inclusion and exclusion criteria. Data were collected in 3 months, at the ending of September 2020, after securing all official permissions to the beginning of January 2021. The researcher visited the study setting three days weekly at morning, afternoon, and night shifts.

The researcher started the assessment of patients by assessing patients' demographic characteristics; it took about 15 minutes to be filled in. The researcher assisted in delivering routine patients' positioning, which was placed on each position in the order (supine, right lateral, left lateral, and semi-recumbent 45 degrees) for two hours.

Ventilation parameters and oxygenation parameters (SPo2) were obtained as the following (T0, T30, T60, T120 minutes). The researcher recorded the ventilation parameters and oxygenation parameters of turning position in the order (supine, right lateral, left lateral, and semi-recumbent position head and torso at the angle of 30-45degree). The researcher recorded the hemodynamics (heart rate and blood pressure) before and after changing each position.

These steps were continued overall 24 hours unless patients were extubated, transferred, or died. Termination of data collection was due upon the completion of the required sample.

4.6. Data analysis

The data obtained were synthesized, analyzed, and presented in tables using the Statistical Package for Social Sciences version 22.0 (SPSS). Qualitative variables were presented in frequencies and percentages; quantitative variables were presented in mean and SD. Analysis of variance (ANOVA) was used to determine whether the means of three or more groups are different. ANOVA uses F-tests to statistically test the equality of means. The confidence interval was set to 95%, and the margin of error accepted was set to 5%. So, the p-value is considered significant at $p \leq 0.05$.

5. Results

Table 1 presents the percentage distribution of the studied patient's demographic data, illustrating that 39.8% of the patients' ages ranged between 45-<65 years old. 52.7% of the patients were males, and the rest (47.3%) of them were females. 72.0% of the studied patients were married, 61.2 % were workers, and 65.6% were smokers. Body mass indices indicate a mean of 26.24 ±2.7.

Table 2 clarifies that 30.1% of the studied patients have a chronic obstructive pulmonary disease, and 76.3% have a history of diabetes mellitus, hypertension 31.8% and 19.4 had pneumonia.

Table 3 reveals the ventilator parameters of the studies subjects that the mean of Vt was 490.0±119.2 ml, PEEP 10.7±1.2 (cm H_2O), FIO_2 0.5, and I/E ratio was 1:2. Regarding the mode of the ventilation, the table also illustrates that 61.3% of the studied patients were on SIMV mode with mean static compliance of 15.4±1.4, respiratory rate was 16.2±3.1, resistive pressure 10.9 ± 3.8 (cmH_2O), and the mean of PaO_2/FiO_2 ratio was 102.4 ± 45.4.

Table 4 shows that the best oxygenation in the supine position was in T0; after that, oxygenation started to decline significantly throughout time. Although oxygenation improved in the right lateral position, it did not significantly increase. Although oxygenation in the left lateral position started to decline at T30, it returned to increase again at T60 and continued to increase with a statistically significant difference overall 120 minutes. In a semi-recumbent position, oxygenation started to increase at T30 continued to increase with a statistically significant difference between measurements overall 120 minutes.

Table 5 indicates that supine and right lateral positions are lowering the heart rate, but they did not reach the significant level, while left lateral and semi-recumbent progressively and significantly increase started at the T30 with statistically significant difference overall 120 minutes.

Table 6 compares the systolic blood pressure in each body position overall 120 minutes. It shows a progressive and significant increase in the systolic blood pressure in supine and left lateral positions, while there is a significant and progressive decrease in the systolic blood pressure in right lateral and semi-recumbent positions. The best systolic blood pressure was in the right lateral position at T120.

Table 7 compares the diastolic blood pressure in each body position overall 120 minutes. The diastolic blood pressure reveals a significant progressive increase in the supine position and an insignificant increase in the left lateral position. In contrast, the diastolic blood pressure reveals a progressive and significant decrease in the right lateral and semi-recumbent position. The best diastolic blood pressure is in the supine position at T0.

Table (1): Frequency and percentage distribution of the studied patients 'demographic characteristics (n=93).

Patient's characteristics	No.	%
Age in years		
<25	9	9.7
25-<45	22	23.7
45- 65	37	39.8
≥65	25	26.9
Gender		
Male	49	52.7
Female	44	47.3
Marital status		
Single	26	28.0
Married	67	72.0
Occupation		
Workers	57	61.2
Non-workers	36	38.7
Smoking		
Smoker	61	65.6
Non-smoker	32	34.4
Weight	83 ± 9.5	
Body mass index	26.24 ±2.7	

Table (2): Frequency and percentage distribution of patients' medical data (n=93).

Patients' Medical data	No.	%
Diagnosis		
Chronic obstructive pulmonary disease	28	30.1
Gastrointestinal disorders	19	20.4
Renal failure	19	20.4
Neurological disorders	12	12.9
Diabetic ketoacidosis	13	14.0
Trauma	2	2.2
Past medical history		
Diabetes Mellitus	71	76.3
Hypertension	29	31.8
Pneumonia	18	19.4

Table (3): Studied patients' ventilator parameters (n=93).

Ventilation parameters	Mean ±SD	
Vt ml	490.0 ± 119.2	
PEEP (cm H_2O)	10.7 ± 1.2	
FIO2	0.5	
I/E ratio	1:2	
Mode of mechanical ventilation		
CMV	36	38.7%
SIMV	57	61.3%
Respiratory rate	16.2 ±3.1	
Static compliance	15.4± 1.4	
Resistive pressure (CmH_2 O)	10.9 ± 3.8	
PaO_2/FiO_2 ratio	102.4 ± 45.4	

Table (4): Comparison of SpO2 in each body position overall 120 minutes (n=93).

SpO2	T0	T30	T60	T120	F	P-value
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD		
Supine	97.51±0.43	97.42±0.49	97.24±1.04	97.21±0.30	4.823	0.003
Right lateral	97.48±1.54	97.50±0.58	97.55±0.61	97.59±0.28	0.291	0.832
Left lateral	97.41±0.32	97.29±0.53	97.32±0.66	97.48±0.74	2.920	0.041
Semi recumbent	97.59±1.41	97.64±1.92	97.73±1.29	98.25±1.73	3.325	0.020

Table (5): Comparison of heart rate in each body position overall 120 minutes (n=93).

Heart rate	T0	T30	T60	T120	F	P-value
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD		
Supine	78.40±3.89	78.37±3.91	78.23±3.92	77.64±3.94	0.762	0.516
Right lateral	79.10±2.59	78.43±2.95	78.27±2.33	77.84±2.14	2.055	0.106
Left lateral	77.64±3.94	78.14±3.92	78.23±2.42	79.10±2.59	3.151	0.02
Semi recumbent	77.84±2.14	78.76±2.44	78.92±2.65	79.22±2.64	4.415	0.005

Table (6): Comparison of systolic blood pressure in each body position overall 120 minutes (n=93).

Systolic blood pressure	T0	T30	T60	T120	F	P-value
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD		
Supine	128.85±3.13	128.93±3.38	129.20±3.21	130.12±3.13	3.059	0.028
Right lateral	130.12±3.13	129.15±3.98	127.73±3.14	127.68±3.35	11.138	<0.0001
Left lateral	127.68±3.35	128.20±2.41	128.48±2.87	129.24±2.36	5.108	0.002
Semi recumbent	129.24±2.36	128.97±3.93	127.92±3.89	127.85±3.61	3.851	0.010

Table (7): Comparison of diastolic blood pressure in each body position overall 120 minutes (n=93).

Diastolic blood pressure	T0	T30	T60	T120	F	P-value
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD		
Supine	77.27±1.23	79.35±1.89	79.89±3.91	80.23±2.13	10.969	<0.0001
Right lateral	80.23±2.13	78.89±3.79	78.62±4.83	78.41±4.78	3.833	0.010
Left lateral	78.41±4.78	78.76±2.02	78.93±2.15	79.46±2.27	1.939	0.123
Semi recumbent	79.46±2.27	78.93±2.78	78.43±3.83	78.27±2.23	3.279	0.021

6. Discussion

The literature supports the benefits of frequent body position changes, particularly for a relatively immobile, unalert, severely debilitated, obtunded patient, breathing at low lung volumes, obese, aged or very young, or has lost the sigh mechanism *(Mehta & Parmar, 2017)*. so, the current study aims to assess the effect of positioning on oxygenation and hemodynamics among patients on mechanical ventilation.

In concern to oxygenation, the result of this study reveals that the best oxygenation was in the semi-recumbent position at T120. The reason may be that the more upright positions are better in the concept of improved ventilatory mechanism and ventilation-perfusion matching. This finding is supported by *Mehta and Parmar (2017)* in a study titled "The effect of positional changes on oxygenation in patients with a head injury in the intensive care unit." They conclude that the upright position significantly increases arterial SpO_2 compared to any other position.

Also, oxygen saturation recorded significant improvement in the left lateral position at T120. This finding may be due to respiratory changes resulting in increased oxygenation by maximizing chest expansion, minimizing abdominal muscular tension, and minimizing the effects of gravity on the chest wall; therefore, it is a useful maneuver for patients in mild to moderate respiratory distress *(Armstrong & Moore, 2020)*.

This finding is also supported by *Ismail et al. (2021)* in a study titled “Effect of body position on oxygenation and hemodynamic status among patients with traumatic brain injury," in which they found that Oxygen saturation and all hemodynamic parameters were significantly improved compared to their normal range in post-semi-fowler position, then right lateral position.

Tongyoo et al.’s (2006) findings suggest that the mean PaO_2 might be increased after turning from supine to the right lateral decubitus position, although this was not statistically significant. There was no change in the other arterial blood gas parameters, respiratory mechanics, or hemodynamics.

In disagreement with *Alan and Khorshid (2021),* a study titled "The effects of different positions on saturation and vital signs in patients.” They conclude that although this difference was not statistically significant, lying on the right side of the body at 45 in bed can effectively improve oxygenation in all patients with lung disease.

While *Hewitt et al. (2016)*, in a study titled "Lateral positioning for critically ill adult patients," found no clear evidence on the effectiveness of routine lateral repositioning or the effects of a single turn for critically ill patients.

According to the effect of positioning on heart rate, this study reveals that supine and right lateral positions decreased the heart rate but did not reach a significant level. In contrast, left lateral and semi-recumbent progressively and significantly increase the heart rate started at the T30 with a statistically significant difference between the four measurements' times. It may be due to an upright upper trunk in Fowler's position that might help to reduce orthostatic stress in frail patients.

This finding is supported by *Daihua et al. (2012)* in their study "The effect of body position changes on stroke volume variation in 66 mechanically ventilated patients with sepsis." They found that body position changes may affect stroke volume variation (SVV) with hemodynamic variables. The 30° head-up and prone positions increased SVV because of the associated decreased stroke volume.

On the other hand**,** ***Kubota et al. (2017)*** reported in a study titled "Assessment of effects of differences in trunk posture during Fowler's position on hemodynamics and cardiovascular regulation in older and younger subjects" that an upright upper trunk during Fowler's position allowed maintenance of stroke volume and inhibited tachycardic response compared to a whole upright trunk regardless of age.

The current study shows a progressive and significant increase in the systolic blood pressure in supine and left lateral positions, while there is a significant and progressive decrease in the systolic blood pressure in right lateral and semi-recumbent positions. This finding may reflect the short-term effect of an improved circulation profile with higher systemic venous return, higher cardiac output, and, therefore, improved oxygen delivery.

This finding is supported by *Göcze et al. (2013)* in a study titled "The effects of the semi-recumbent position on hemodynamic status in patients on invasive mechanical ventilation: Prospective randomized multivariable analysis," they showed significantly higher values for mean arterial pressure (MAP) and central venous oxygen saturation (ScvO2) in the supine position.

The same was observed in *Baysal et al.'s study (2017)* that mean systolic/diastolic blood pressure and dyspnea severity of patients were highest in the supine position and lowest after 15 minutes of the orthopnic position.

Also supported by *Anchala (2016)*, who assesses the effect of therapeutic positions on hemodynamic parameters among critically ill patients in the intensive care unit at Sri Ramachandra Medical Centre. They reported a significant difference in systolic blood pressure in the left lateral position and oxygen saturation in semi fowler's position, which is also supported by *Göcze et al. (2013),* who concluded that adopting the 45° semi-recumbent position is strongly associated with decreases in MAP and $ScvO_2$ in mechanically ventilated patients.

On the other hand, *Aries et al. (2012)*, in a study titled "Intra-arterial blood pressure reading in intensive care unit patients in the lateral position." They reported that turning hemodynamically stable patients in the intensive care unit has no important effects on blood pressure measurements when continuous hydrostatic height correction is applied.

In concern to time, these changes in systolic blood pressure were started immediately at each position change with a statistically significant difference between the measurement times T0, T30, T60, T120.

Regarding diastolic blood pressure, the current study shows that the diastolic blood pressure revealed a significant progressive increase in the supine position and an insignificant increase in the left lateral position. In contrast, the diastolic blood pressure reveals a progressive and significant decrease in the right lateral and semi-recumbent position. Those changes started immediately at each position change with a statistically significant difference between the measurement times T0, T60, T120. This finding may be due to alters inflow into the right heart and outflow from the left heart. Alterations in transpulmonary pressure can alter the outflow from the right heart and the inflow to the left heart.

This finding is supported by *Islam et al. (2018)* in a study titled "Variation of blood pressure during change of posture," they concluded that BP significantly varies according to body position. Despite a minor BP variation in most of the studied population, a small proportion of subjects showed large differences in BP from one position to another.

Also, *Cicolini et al. (2011)*, in a study titled "Differences in blood pressure by body position (supine, Fowler's, and sitting) in hypertensive subjects." They conclude that Fowler's position may represent a valid alternative to sitting and supine positions for BP measurement in clinical practice.

On the other hand, *Privšek et al. (2018)*, in a study titled "Epidemiological and clinical implications of blood pressure measured in seated versus supine position." They concluded that there is a significant difference in blood pressure between seated and supine positions. Measuring blood pressure in the supine position shows lower blood pressure readings when compared with the seated position.

7. Conclusion

This study concluded that the positioning had a different effect on oxygenation and hemodynamics among mechanically ventilated patients. It revealed the effect of the supine position, which was the best oxygenation level at the T0, then declined progressively and significantly. At the same time, a significant and progressive increase in oxygenation was observed in a semi-recumbent position, with the best oxygenation was set at T120.

The heart rate was significantly and progressively increased in semi-recumbent and left lateral positions. Significant systolic and diastolic variation in almost all positions at different measurements. Systolic blood pressure increased significantly and progressively in supine and left lateral positions and decreased significantly in right lateral and semi-recumbent positions. Diastolic blood pressure was significantly and progressively increased in the supine position and decreased significantly and progressively in the right lateral position and semi-recumbent position.

8. Recommendations

- Positioning should be involved in managing critically ill patients as a therapeutic tool to be matched with the therapeutic goal.
- The time of changing position should be reviewed to be compatible with the most effective position for mechanically ventilated patients and according to the patient clinical need.
- The same study could be replicated in more hospitals with a larger probability sample for further research.

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