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The Effect of Patient Position on Perfusion Index

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Abstract: **Introduction:** Positioning patients safely for surgical procedures is a routine intraoperative responsibility and facilitating positive patient outcomes is an expected standard of professional care. Measuring peripheral perfusion index (PPI) during the different surgical positions to assess the influence of body position on perfusion index is the focus of this study. **Patients and method:** It is a prospective observational study involved 80 patients. The participants were patients for different elective surgeries. Each participant was taken to the recovery room, the environmental temperature was ensured to be from (22-23°C) during the whole session and for each one. For each participants PI, blood pressure, pulse rate, and SpO_2 were measured for each of the four surgical positions: supine, sitting, prone, and lithotomy. The probe of oximeter was put in the middle finger for all participants. All the measurements were taken by the researcher. **Results:** PI was significantly lower in sitting and prone position in comparison to supine position (P=<0.001 respectively). Systolic and diastolic blood pressure was significantly higher in supine position than sitting position (P=<0,001, and 0,024 respectively). Pulse rate was significantly lower in supine position than sitting and prone position (P=<0.001 respectively). SpO_2 showed no significant differences among the different surgical positions. **Conclusion:** Surgical patient position affects perfusion index. Blood pressure and pulse rate affected by surgical patient position, usually due to compensatory response (reduction in venous return or venous compression).

Keywords: Position, Perfusion Index.

INTRODUCTION

Monitoring of tissue perfusion is an essential step in the management of acute circulatory failure. The presence of cellular dysfunction has been a basic component of shock definition even in the absence of hypotension (Vincent, J. L. *et al*., 2015). The ideal parameter for tissue perfusion should be rapid, non-invasive, and easily measured without the need of advanced skills. Evaluation of tissue perfusion includes clinical evaluation as well as biomarkers. Popular biomarkers of tissue perfusion such as serum lactate and central venous oxygen saturation are indicators of global tissue perfusion. Monitoring of peripheral circulation especially in non-vital organs added new insights for monitoring of tissue perfusion. Peripheral non-vital organ Perfusion deteriorates earlier and improves later than vital organs. Assessment of peripheral circulation has become easier after introduction of new non-invasive devices as well as clinical scoring systems (Hasanin, A. *et al*., 2017).

Hemodynamic monitoring in the perioperative phase traditionally relies on simple and readily available parameters such as blood pressure and heart rate. Clinical findings such as skin temperature, capillary response, color, mottling, diuresis, perfusion index, and lactatemia can sometimes provide additional information, although typically with a rather long temporal resolution. Even short periods of intraoperative cardiovascular instability have been associated with increased morbidity and mortality (Sessler, D. I. *et al*., 2018). Advanced monitoring focusing on optimizing systemic hemodynamics is gaining popularity (Vincent, J. L. *et al*., 2015).

Peripheral perfusion index (PPI) is one of the non-invasive markers of local perfusion (Van Genderen, M. E. *et al*., 2013). The change in perfusion index (PI) reflects the change in other measures of hypoperfusion such as lactate, P (v-a) CO_2 (He, H. *et al*., 2015), and temperature gradients (Lima, A. P. *et al*., 2002). PI less than 1.4 is a marker of hypoperfusion in patients with critical illness (Lima, A. P. *et al*., 2002); also, PI less than 0.6 is an independent factor for 30-day mortality (He, H. *et al*., 2015). In septic shock patients, PI less than 0.3 predicted vasopressor therapy (Rasmy, I. *et al*., 2015) and below 0.2 is a prediction for mortality (He, H. W. *et al*., 2013).

According to the surgeon's preference, patients put in supine, prone, sitting, lateral, lithotomy, Trendelenburg or reverse Trendelenburg position. Different respiratory and hemodynamic changes take place dependent on the patient's surgical intraoperative position, which insists on the importance of knowing the possible physiological effects of each position (Tapar, H. *et al*., 2018). Most common intraoperative positions (i.e., supine, prone, lateral, sitting, lithotomy) adversely affect the respiratory system by interfering with a patient's ventilatory efforts (Arthur, A. *et al*., 2018). Closure of the alveoli and abnormal

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distribution of inspired air will occur due to decreased lung expansion (Gibson, G. J. *et al*., 1976).

AIM OF THE STUDY

Measuring peripheral perfusion index (PPI) during the different surgical positions to assess the influence of body position on perfusion index is the focus of this study.

PATIENTS AND METHODS

It is a prospective observational study involved 80 patients. The participants were patients for different elective surgeries. After obtaining the approval of the Iraqi Scientific Council of Anesthesia and Intensive Care, the study was conducted in Al Kadhimiya teaching hospital from the beginning of May 2021 to the end of September 2021.

Inclusion Criteria:

- Age (18-45) years old.
- ASA1.
- Fasting >3 hours.
- Normal BMI.
- Were able to communicate and cooperate.

Exclusion Criteria:

- With peripheral circulatory disorders.
- With cardiac, circulatory, respiratory, neurological, and psychiatric problems.
- BMI > 30.
- Smoking habits.
- With Anemia.
- With systolic blood pressure (SBP)<100 mmHg.

The data was collected using a structured questionnaire. Through three days chosen conveniently from each week and from 9:00 am to 2:00 pm during the study period. Any patient admitted through these hours for elective surgery for different causes and fitted the inclusion criteria and accepted to participate in the study were included. The questionnaire consisted of two parts; the first one for demographic characteristics include age, sex, and BMI and the second one included surgical position (supine, sitting, prone, and lithotomy) and their corresponding measurements (perfusion index, blood pressure, heart rate, and SpO_2) for each position.

Each participant was taken to the recovery room, the environmental temperature was ensured to be from (22-23°C) during the whole session and for each one.

For each participant, the following steps have been implemented:

1. Putting the participant in supine position waiting for 5 minutes for resting and then the Perfusion Index (PI), blood pressure, heart rate and SpO_2 were measured and reported.
2. Changing to sitting position at 45-degree back-up waiting for two minutes and then the Perfusion Index (PI), blood pressure, heart rate and SpO2 were measured and reported.
3. Repositioned the participants to supine position and waiting for five minutes resting.
4. Changing to prone position and after two minutes the Perfusion Index (PI), blood pressure, heart rate and SpO2 were measured and reported.
5. Repositioned the participants to supine position and waiting for five minutes resting.
6. Changing to lithotomy position and after two minutes the measurement of the Perfusion Index (PI), blood pressure, heart rate and SpO2 were repeated and reported.

These repeated repositioning of the participant to supine position before assignment to the new position was according to what established in a work by (Tapar, *et al*., 2018) to stabilize the circulatory condition.

The probe of oximeter was put in the index finger for all participants. All the measurements were taken by the researcher.

The participation in the study was optional. The objectives of the study were explained to the patients by the researcher. A verbal consent was taken from all the patients who decided to participate in the study. All the participants were given a complete unconditioned choice to participate in the study. They were allowed to leave at any time they feel uncomfortable. A complete confidentiality was ensured. The participants were informed that the personal information will be collected with serial identification numbers without an identity and all of the collected data will used for research purpose only.

Data were introduced into Microsoft excel sheet 2019 and loaded into SPSS (Statistical Package for Social Sciences) version (24). Parametric data are presented as mean and standard deviation. Categorical data presented as numbers and percentages. Chi- square test and Fisher exact test was used to test homogeneity. Independent t-test was used to measure the difference between

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groups' parametric variables. P-value < 0.05 was considered significant.

RESULTS

In this study a total of 80 patients were participated. The patients were admitted for elective surgeries and the measurements were taken per-operatively. The patients were 39 males to 41 females, with mean age (33.04 ± 5.554) and mean BMI (23.53 ± 2.106) as clarified in table 1.

Table 1: Baseline characteristics of study participants (n = 80)

Characteristics	N. (Mean ± SD)
Male / Female	39/41
Age (by Years)	(33.04 ± 5.554)
BMI	(23.53 ± 2.106)

In the comparison of hemodynamic changes between the different body positions for the same patient it showed that the mean Perfusion index was the lowest in the Sitting position (4.130 ± 0.399) and the highest in the Lithotomy position (8.251±0.593), while the mean Systolic Blood Pressure was the highest in Supine position and Lithotomy position [(121.80±7.20), (118.24 ± 6.09)] and the lowest in Sitting and Prone position [(115.18±6.53), (115.01±7.54) respectively].

Also, mean Diastolic Blood Pressure was the highest in Supine position and Lithotomy position [(76.56±8.02), (77.24 ± 7.31)] and the lowest in Sitting and Prone position [(74.41±5.54), (73.53±6.21) respectively].

The mean Pulse Rate was almost higher in Supine position (79.25±5.52), and Sitting position (80.58 ± 4.78), and lower in Prone position (80.15±5.25), and Lithotomy position (78.58±5.66).

Regarding mean SpO2 level was also the same in all positions [Supine (98.09±0.69), Sitting (97.25±0.97), Prone (97.59±0.83), and Lithotomy (97.23±0.96)]. As illustrated in table 2.

Table 2: Comparison of hemodynamic changes in different body positions (n=80)

Measurements (Mean ± SD)	Body positions				
	Supine	**Sitting**	**Prone**	**Lithotomy**	**P-value**
Perfusion Index	6.251±0.477	4.130±0.399	5.283±0.377	8.251±0.593	< 0.001
Systolic Blood Pressure	121.80±7.20	115.18±6.53	115.01±7.54	118.24±6.09	< 0.001
Diastolic Blood Pressure	76.56±8.02	74.41±5.54	73.53±6.21	77.24±7.31	< 0.001
Pulse Rate	79.25±5.52	80.58±4.78	80.15±5.25	78.58±5.66	0.005
SpO_2	98.09±0.69	97.25±0.97	97.59±0.83	97.23±0.96	0.079

The comparison of Perfusion Index in different body position of the same patient in relation to the Supine position it showed that the Perfusion Index was statistically significant lower in Sitting position compared to Supine position (P=<0.001), and statistically significant lower in Prone position compared to Supine position (P=<0.001). Whereas Perfusion Index in Lithotomy position was significantly higher than Supine position (P=0.009), as clarified in figure 1.

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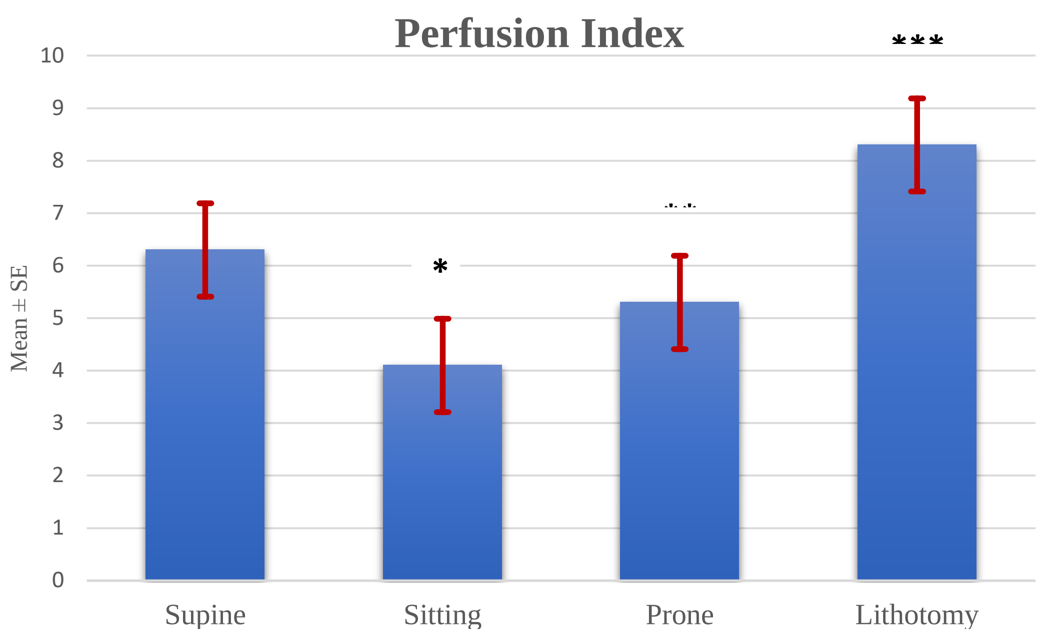
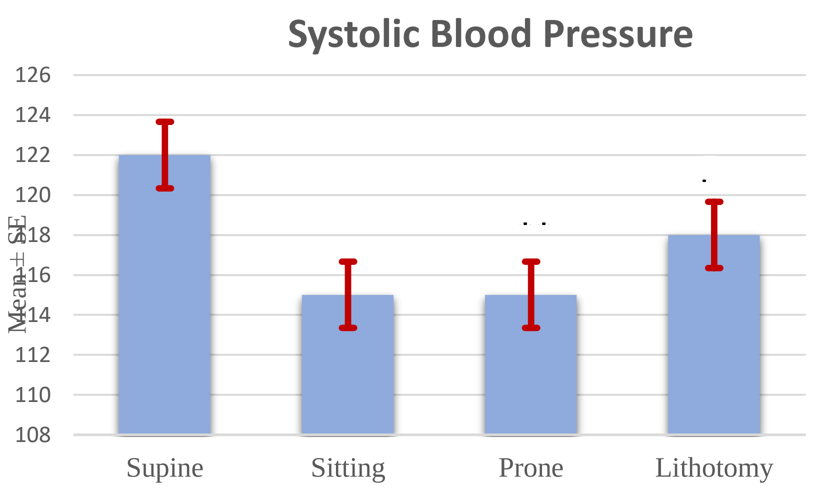


The following comparisons between Perfusion Index in different body positions in relation to Supine position are found statistically significant:
*Supine - Sitting: p = < 0.001
**Supine- Prone: p = < 0.001

Figure 1: Comparison of Perfusion Index in different body position by repeated measures ANOVA test.

The comparison of Systolic Blood Pressure in different body position of the same patient in relation to the Supine position it showed that the SBP was significantly higher in Supine position compared to Sitting position (P=<0.001), and statistically significant lower in Prone position compared to Supine position (P=<0.001), and in Lithotomy position (P=0.009), as clarified in figure 2.



The following comparisons of Systolic blood pressure in different body positions in relation to Supine position are found statistically significant:
*Supine - Sitting: p = < 0.001

Figure 2: Comparison of Systolic Blood Pressure in different body position by repeated measures ANOVA test.

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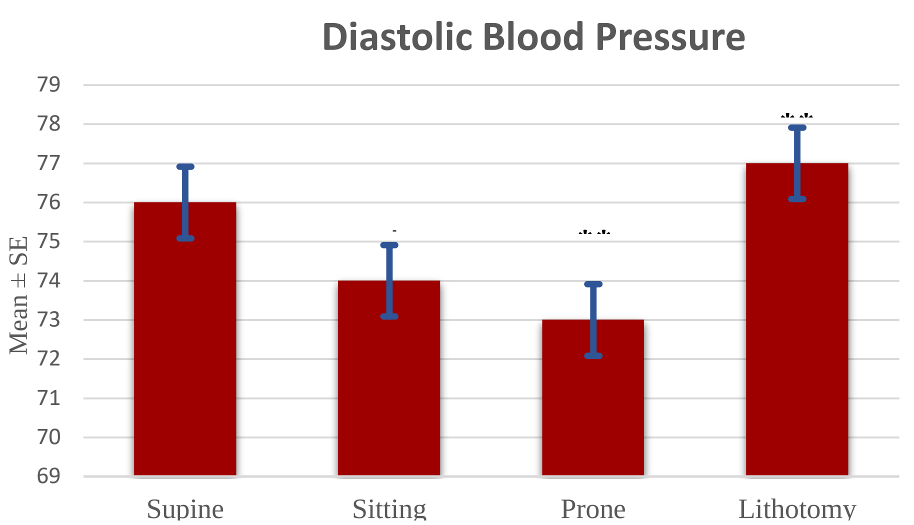
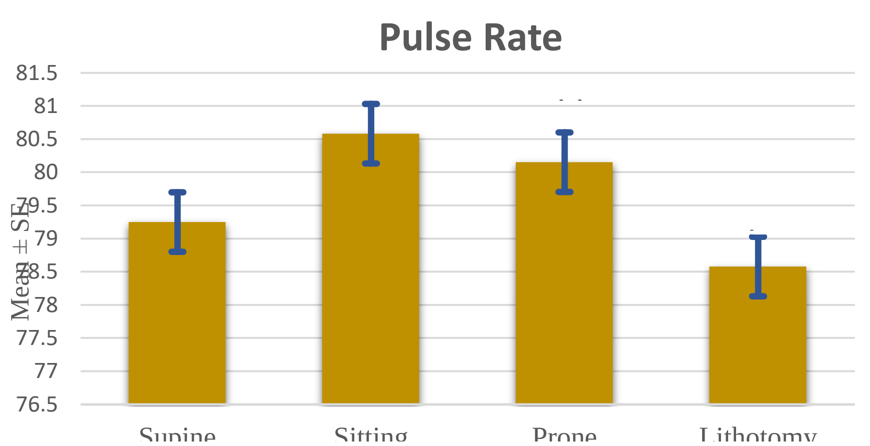
The comparison of Diastolic Blood Pressure in different body position of the same patient in relation to the Supine position it showed that the DBP was statistically significant lower in Sitting position and Prone positions compared to Supine position (P = < 0.024 and < 0.001 respectively), whereas DBP in Lithotomy position was significantly higher than Supine position (P = <0.001), as clarified in figure 3.



The following comparisons of Diastolic blood pressure in different body positions in relation to Supine position are found statistically significant at:
*Supine - Sitting: p = 0.024

Figure 3: Comparison of Diastolic Blood Pressure in different body position by repeated measures ANOVA test.

The comparison of Pulse Rate in different body position of the same patient in relation to the Supine position it showed that the PR was statistically significant higher in Sitting position and Prone positions compared to Supine position (P=<0.001 for each), whereas PR in Lithotomy position was significantly lower than Supine position (P= 0.03), as clarified in figure 4.



The following comparisons of Pulse rate in different body positions in relation to Supine position are found statistically significant at:
*Supine - Sitting: p = < 0.001
**Supine- Prone: p = < 0.001

Figure 4: Comparison of Pulse Rate in different body position by repeated measures ANOVA test.

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The comparison of SpO_2 in different body position of the same patient in relation to the Supine position it showed no statistical significant differences between Sitting, Prone, and Lithotomy in relation to Supine position (P = 0.199, 0.490, and 0.185 respectively), as clarified in figure 5.

The following comparisons of SpO_2 in different body positions in relation to Supine position are found statistically significant at:
*Supine - Sitting: p = 0.199
**Supine- Prone: p = 0.490
***Supine - Lithotomy: p = 0.185

Figure 5: Comparison of SpO_2 in different body position by repeated measures ANOVA test.

DISCUSSION

This study showed that Perfusion Index values among patients before their elective surgeries, varied according to the surgical body position by using supine position measurements as a baseline. The findings showed a relationship between different surgical body position and perfusion index, systolic and diastolic blood pressure, and pulse rate, but the relation between surgical body position and SpO_2 was not significant.

In our study PI was significantly lower in sitting position than supine (P=<0.001), and in prone than supine position (P=<0.001), while in lithotomy position Perfusion Index were slightly higher with a significant difference (P= 0.009). The explanation behind these findings could be attributed to the fact that Perfusion Index is affected by vasoconstriction that happen with changing body position (Lima, A. P. *et al.*, 2002). Vasoconstriction can happen when there is a perfusion impairment caused by circulatory disorders associated with hypovolemia and low cardiac output in which the blood will shifted to vital organs from the non-vital organs, resulting in redistribution of blood and causes a reduction in Perfusion Index value (Lighthall, G. K. *et al.*, 2014). Cardiac output is the only parameter that affects both blood pressure and blood oxygen perfusion (Lighthall, G. K. *et al.*, 2014; Hernandez, G. *et al.*, 2013).

So, any decrease in the preload and contractility of the heart causes a decrease in cardiac output, as a physiological response the body will increase cardiac contractility, systemic vascular resistance, and heart rate through baroreceptors to increase cardiac output (Armstrong, M. *et al.*, 2021) and this will lead to vasoconstriction and affect Perfusion index values.

Buhre, *et al.*, was reported in their study that cardiac index, pulmonary, and total blood volume decreased in sitting position after change from supine position and clarified this as a potential association with lower cardiac output and increased vascular resistance as compensatory mechanisms.

Regarding the effect of different surgical body positions on the blood pressure, in our study it showed a significant difference where systolic and diastolic blood pressure decreases in sitting and prone position in comparison to supine position (P=<0.001, and <0.001 respectively). And these results were like various studies conducted to compare BP values in sitting or supine positions,

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and reported variations ranged from 0 to 10 mmHg (Netea, R. T. *et al*., 2003; Eşer, İ. *et al*., 2007). In these studies, systolic blood pressure was higher in supine than sitting position (Netea, R. T. *et al*., 2003-Sala, C. *et al*., 2005). In a study by Cicolini *et al*., they reported a significant reduction in systolic and diastolic blood pressure when changing patient position from supine to sitting and semi-sitting positions, the influence of body position on systolic blood pressure was clinically weighty in 15–30% of the subjects, who exposed a difference in SBP ≥10 mmHg from one position to another (Cicolini, G. *et al*., 2011).

The reason that sitting position can causes blood pressure fluctuations, is the change of body position would cause a reduction in venous return and a subsequent dropping in the cardiac output where the blood accumulates in the lower extremities and in the abdominal vasculature.

The reduction in blood pressure in prone position in comparison to supine position can be attributed to the high thoracic pressure the position produces, which affect arterial filling and left ventricular compliance.

In our study Pulse rate were significantly increases in sitting and prone position in comparison to supine position (P=<0.001 for each). This finding was similar to a study by Pumb, *et al*., 2002, where reported a significant higher pulse rate in sitting and prone positions, and a study by Hnatkova, *et al*., (2019), which heart rate were increase by 10 bpm in sitting position compared to supine position. The possible theoretical possibility is that in sitting position causes venous return and the blood shifted to the extremities and abdomen by the effect of gravity, and as a result cardiac output will increase, with increase in heart rate will occur to keep blood flow to the vital organs (e.g., heart and brain) (Anderson, R).

The explanation for increasing heart rate in prone position is the possible theory that compression of the thorax in prone position reported in a slight but significant decline in stroke volume (Pump, B. *et al*., 2002). The drop in stroke volume may suggest a reduction in arterial filling and pulse rate leading to inhibition of the arterial baroreceptors, and causing increase in heart rate, and total peripheral vascular resistance (Pump, B. *et al*., 2002; Norsk, P. *et al*., 2020).

Regarding SpO_2 our study shows no significant differences in SpO2 level for different body position in comparison to supine position. Our findings were a similar to what reported in a study by Jones, *et al*., (2004) which showed no significant differences of oxygen saturation in different body positions and the study were conducted on healthy subjects. While in other studies were conducted by Wright, *et al*., 2011; and Masuda *et al*., (2014) and reported that blood oxygenation level and SpO_2 values were higher in prone position, the explanation behind the difference in findings could be that in both studies, the study population were patients with pulmonary diseases rather than a healthy subjects.

CONCLUSION

Surgical patient position affects perfusion index. The highest perfusion index values were spotted in lithotomy and supine positions, and the lowest in sitting and prone position with a significant difference in comparison to Supine position.

Blood pressure and pulse rate affected by surgical patient position, blood pressure was the highest value in supine and lithotomy positions, while pulse rate was the highest at sitting and prone positions, usually due to compensatory response (reduction in venous return or venous compression).

SpO_2 values were not affected by changing the surgical position of the study participants.

RECOMMENDATION

Our recommendation from the experience in conducting this study that peripheral perfusion index is an easy, not expensive, objective tool, with low time consuming, it can be a non-invasive, continuous, and important monitor for estimating peripheral perfusion for surgical patients whose position might change throughout the surgery and affecting their PI value and requires a new baseline to follow up the perfusion index.

Peripheral perfusion index measures peripheral distribution rather than central and start as a first value to be influenced by perfusion reduction, we recommended using other methods like lactate for measuring hemodynamic distribution when PI show a reduced value.

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