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Research Article

The effect of overweight and patient position changes on perfusion index after anesthesia induction

Fazla kilo ve hasta pozisyon değişikliklerinin anestezi indüksiyonundan sonra perfüzyon indeksi üzerindeki etkisi

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Abstract

Aim: The relative variability in the perfusion index (PI) observed after anesthesia induction, due to the effect of surgical positions, is influenced by multiple factors. The aim of this study was to investigate changes in PI in patients undergoing surgery in the supine, prone, and sitting positions, and to assess the effect of body mass index (BMI) on the relative change in PI (ΔPI).

Material and Methods: This is a prospective cross-sectional observational study. A total of 82 patients were enrolled between June 2023 and December 2023, including individuals over 18 years of age. The study investigated the effects of different patient positions (supine, sitting, and prone) and BMI on the relative change in perfusion index.

Results: Of the patients, 52.4% were male (n = 43). It was found that 43.9% of the patients had a BMI greater than 25 kg/m^2 (n = 36). The operations were performed in the prone position in 32.9% of cases (n = 27), supine position in 32.9% (n = 27), and sitting position in 34.1% (n = 28). No statistically significant difference was observed in the PI value at 0 minutes across all groups. The PI values at 10, 20, and 30 minutes were highest in Group 1 patients. It was found that the PI values were statistically higher in patients with a BMI <25 at all time intervals ($p < 0.001$). The ability of a BMI of 25 or greater to predict ΔPI after anesthesia induction was analysed, and the area under the ROC curve showed a sensitivity of 91% and specificity of 93%. The cut-off value, according to the maximum Youden index, was 0.96, with a confidence interval of 91-99% ($p < 0.001$).

Conclusion: The change in the PI value after anesthesia induction was found to be greater in patients positioned prone. This change significantly impacts ΔPI, particularly when the BMI ≥ 25 cut-off is applied.

Keywords: patient positions, perfusion index, obesity, anesthesiology

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Öz

Amaç: Anestezi indüksiyonundan sonra cerrahi pozisyondaki değişiklikle gözlenen perfüzyon indeksi (PI) değerindeki değişiklik birçok faktörden etkilenir. Bu çalışmanın amacı sırtüstü, yüzüstü ve oturma pozisyonlarında ameliyat edilen hastalarda PI'daki değişikliği ve vücut kitle indeksinin (VKİ) PI'daki (ΔPI) bağıl değişiklik üzerindeki etkisini araştırmaktır.

Gereç ve Yöntemler: Bu prospektif kesitsel gözlemsel bir çalışmadır. Haziran 2023 ile Aralık 2023 arasında 18 yaş üstü, sırtüstü, oturma ve yüzüstü pozisyonlarda olmak üzere toplam 82 hasta kaydedildi ve hasta pozisyon değişiklikleri ve VKİ değerlerinin ΔPI üzerindeki etkileri araştırıldı.

Bulgular: Hastaların %52,4'ünün erkek olduğu (n: 43) görüldü. Hastaların %43,9'unun (n:36) BKİ'sinin 25 kg/m2'nin üzerinde olduğu görülmüştür. Cerrahi operasyonlar %32,9 yüzüstü pozisyonda (n:27), %32,9 sırtüstü pozisyonda (n:27) ve %34,1 oturur pozisyonda (n:28) gerçekleştirilmiştir. Tüm gruplarda PI 0 değerinde istatistiksel olarak anlamlı bir fark olmadığı görülmektedir. PI 10-20-30 değerinin grup 1 hastalarında en yüksek düzeyde olduğu görülmektedir. Tüm zaman aralıklarında BKİ <25 olan hasta gruplarında PI değerlerinin istatistiksel olarak daha yüksek olduğu görülmektedir (p<0,001). BKİ 25 olan hastaların anestezi indüksiyonu sonrası ΔPI'yi tahmin etme yeteneği incelendiğinde, ROC eğrisi altında kalan alanın duyarlılığı %91, özgüllüğü ise %93 olarak bulunmuştur. Maksimum Youden indeksine göre kesme değeri %91-99 güven aralığıyla 0,96'dır (p<0,001).

Sonuç: Anestezi indüksiyonundan sonra PI'deki bağıl değişimin yüzüstü pozisyondaki hastalarda daha yüksek olduğu bulunmuştur. BMI≥25 kesme değeri kabul edilirse bu değişim ΔPI'yi yüksek oranda etkiler.

Anahtar Kelimeler: hasta pozisyonları, perfüzyon indeksi, obezite, anesteziyoloji

Introduction

It is common for certain vital signs to be affected after anesthesia induction, with hypotension and bradycardia being the most common. Several factors can contribute to the hypotensive effects of anesthetic induction [1]. In obese patients, hemodynamic parameters are influenced by changes in patient position during surgery. Blood pressure abnormalities after anesthesia induction are common in obese individuals. Additionally, bradycardia and hypotension may occur due to reduced venous return to the heart, which is caused by increased intrathoracic pressure during mechanical ventilation. This may lead to changes in the pulmonary vascular system and the patient's hemodynamics. In addition to these effects, the position in which the patient is placed during anesthesia may reduce venous return to the heart, alter ventilation and perfusion in the dependent regions of the lungs, and influence hemodynamic parameters [2]. Obesity is assessed using the Body Mass Index (BMI), which is calculated by dividing a person's body weight by the square of their height (kg/m^2). Individuals with a BMI greater than 30 are classified as obese [3]. Obese patients are at increased risk of certain complications during anesthesia, such as difficulties with intubation and mechanical ventilation. In addition, compared to patients with a normal BMI, they tend to have higher peak airway pressures during mechanical ventilation and may experience lower blood pressure [4]. Hypotension and reduced venous return to the heart in obese patients can increase myocardial workload and oxygen demand [5-6]. The Perfusion Index (PI) is the ratio of pulsatile to non-pulsatile blood flow, as measured by pulse oximetry. It is commonly used to assess peripheral perfusion and sympathetic nervous system activity. The Pleth Variability Index (PVI) quantifies changes in the amplitude of the plethysmographic waveform in response to respiratory variations and is considered to reflect intravascular volume status [7].

The hypothesis of our study was that changes in body position after the induction of general anesthesia, as well as obesity, influence the perfusion index (PI) values. In this study, we investigated changes in hemodynamic parameters and PI values in patients with a BMI of 25 or higher and those with a normal BMI, following anesthesia induction in the prone, sitting, and supine positions.

Material and Methods

Study design

We conducted a prospective, cross-sectional observational study, and obtained ethics committee approval from the Amasya University Ethics Committee (Approval No: 2023000046-1).The study adhered to the ethical principles outlined in the declaration of Helsinki. The study was registered

at ClinicalTrials.gov (ID: NCT96742619). In preparing our report, we adhered to the CONSORT checklist and followed the guidelines outlined in the STROBE statement. Written consent was obtained from all participants.

Inclusion criteria

A total of 82 patients aged over 18 years were enrolled between June 2023 and December 2023. The study included patients undergoing laparotomy in the supine position, shoulder surgery in the sitting position, and lumbar disc herniation surgery in the prone position.

Exclusion criteria

Patients under 18 years of age, those with peripheral circulation problems, heart failure, or heart valve disease, and patients unable to orient themselves were excluded from the study.

Patient and data collection

Patients scheduled for surgery in the prone position were classified as Group 1, those scheduled for surgery in the sitting position as Group 2, and those scheduled for surgery in the supine position as Group 3. All patients were then transferred to the operating room. Peripheral intravenous (IV) access was established using a 20 Gouge IV cannula. Patients were fasted for 6 hours and administered 500 cc of lactated Ringer's solution intravenously prior to transfer to the operating room.

Protocol

Premedication was administered 10 minutes prior to surgery with 1 mg IV midazolam and 40 mg IV pantoprazole. Routine monitoring included electrocardiography (ECG), oxygen saturation (SpO_2), pulse oximetry, non-invasive blood pressure (NIBP), and mean arterial pressure (MAP), all of which were recorded. PI and Pleth Variability Index (PVI) values were measured using the finger probe of a PI device (Masimo Corp, Irvine, CA, USA) placed on the right index finger. All values were recorded at minute 0. Body Mass Index (BMI) values (kg/m^2) were calculated using height and weight measurements for all participants. Preoperative data including age, sex, room temperature, and BMI were also recorded.

For anesthesia induction, propofol 1.5-2 mg/kg IV, fentanyl 1-2 mcg/kg IV, and rocuronium 0.6 mg/kg IV were administered, followed by bag-mask ventilation. After achieving muscle relaxation, patients were intubated and connected to a mechanical ventilator. A 50% oxygen (O_2)-air mixture was administered, with tidal volume set to 6-8 ml/kg, frequency 12-15/min, PEEP: 5 cm H_2O, and sevoflurane 2% MAC was used to maintain anesthesia. The patient was positioned in either the supine, prone, or sitting position for surgery. HR, SpO_2, MAP, PI, and PVI values were recorded at 10, 20, and 30 minutes post-positioning.

During the intraoperative period, Ringer's lactate was infused at 4-8 ml/kg/min, with 250 ml administered if MAP was <65 mm Hg. If MAP remained <65 mm Hg despite fluid administration, 1-2 mg of norepinephrine was given intravenously. At the end of the surgical procedure, the muscle relaxant effect was reversed with 200 mg IV sugammadex. Patients with adequate spontaneous respiration and muscle strength were extubated and transferred to the post-anesthesia care unit.

HR, MAP, PI, and PVI values were recorded at 10, 20, and 30 minutes. The relative change in PI value (ΔPI) at 30 minutes post-surgery was calculated using the formula: $\Delta PI = (PI_{30} - PI_0) / PI_0$.

Statistical Analysis

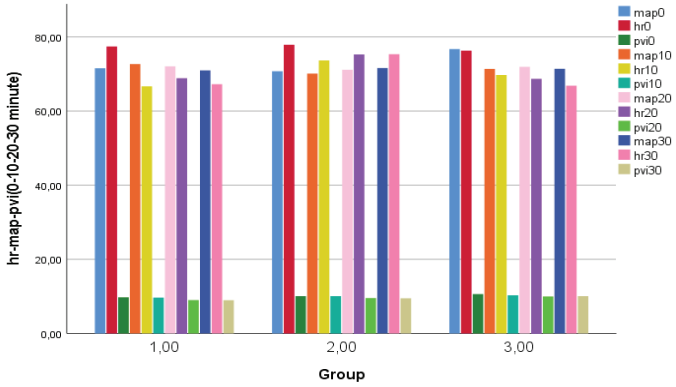
The study by Min JY et al [8] was used to calculate the sample size. The sample size of patients was calculated using G-Power 3.1.9.4. The effect size was calculated to be 0.39 with a type 1 error of 0.05 (the power of the study was 0.80) and the total number of patients was 80. To avoid missing data, 82 patients were included in the study. Data were analysed using IBM SPSS statistical package, version 25.0 (Chicago, IL, USA). Kolmogorov-Smirnov tests were used to analyse the normality of the data distribution. Continuous numerical data were expressed as standard deviation and median range. Demographic characteristics were summarised as frequency percentages. One-way ANOVA analysis with post-hoc Bonferroni correction was used to analyse group variables. Independent samples t-test and Mann-Whitney U test were used to analyse PI values at different time points in patients with normal and above normal BMI values. Pearson correlation analysis was used to determine the possible relationship between BMI and relative change in PI. A value of $p<0.05$ was considered statistically significant. An ROC curve was calculated using the best cut-off value. A BMI of 25 or higher was used as the cut-off value. Youden index to measure the ability of BMI variability to predict ΔPI after induction of anesthesia.

Results

A total of 82 patients data were analysed. It was found that 52.4% of the patients were male (n: 43). It was found that 43.9% of the patients had a BMI greater than 25 kg/m2 (n: 36). The operation was performed in 32.9% prone position (n: 27), 32.9% supine position (n: 27) and 34.1% sitting position (n: 28). Age, sex, BMI and room temperature of the groups were presented in Table 1.

Table 1. Demographic characteristics and room temperature values.		
	n	Mean±SD
Gender M/F	43/39	
Age (years)		45.5±16.7
BMI (kg/m2)		25.09±4.2
Room temperature°C		22.5±1.3
M:male, F:female, BMI:Body mass index, SD:Standard deviaation		

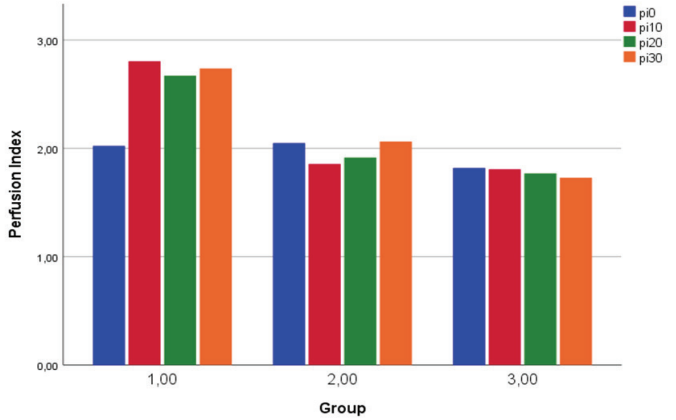
The PI values at 0, 10, 20 and 30 minutes are presented in Figure 1 (PI 0, PI 10, PI 20 and PI 30) for each group. No statistically significant difference was observed in the PI 0 values across the groups. The PI 10 value was higher in Group 1 patients ($p < 0.001$), with no difference observed between Groups 2 and 3 ($p = 0.967$). Similarly, the PI 20 value was higher in Group 1 patients ($p = 0.002$), with no difference observed between Groups 2 and 3 ($p = 0.758$). The PI 30 value was higher in Group 1 patients ($p < 0.001$), with no difference observed between Groups 2 and 3 ($p = 0.407$).



Map:Mean arterial pressure, hr:Heart rate, pvi: pleth variability index

Figure1: Comparison of PI values of groups at different time points

MAP, HR, and PVI values are presented in Figure 2. No statistically significant differences were observed across the groups at any time during anesthesia.



Pi: perfusion index

Figure 2: Comparison of hemodynamic parameters of groups at different time points

The PI values at 10, 20, and 30 minutes after anesthesia induction in patients with BMI values above normal (≥25 kg/m^2) and below normal (<25 kg/m^2) are presented in Table 2. It was observed that PI values were statistically higher in patients with BMI <25 at all time intervals ($p < 0.001$ for all comparisons).

Table 2. Comparison of PI values in patients with BMI ≥25 and BMI<25.				
Gropus	N	Mean Rank	Sum of Ranks	p
		PI 0		
BMI≥25	36	18.7	674.5	<0.001
BMI<25	46	59.3	2728.5	
		PI 10		
BMI≥25	36	24.8	894.5	<0.001
BMI<25	46	54.3	2508.5	
		PI 20		
BMI≥>25	36	21.1	756.5	< 0.001
BMI<25	46	57.3	2646.5	
		PI 30		
BMI≥25	36	18.9	681.0	<0.001
BMI<25	46	59.1	2722.0	
BMI: Body Mass Index. PI:perfusion Index				

There was a moderate negative correlation between BMI and ΔPI values (Pearson correlation coefficient - 0.76 and p<0.001). The rate of patients with a body mass index ≥25kg/m2 was 43.9% (n:26). To examine the change in PI value after induction of anesthesia according to the BMI variable, a ROC curve was constructed. The ability of patients with BMI of 25 to predict the ΔPI after induction of anesthetic was investigated. The area under the ROC curve showed a sensitivity of 91% and a specificity of 93%. The cut-off value according to the maximum Youden index was 0.96 with a confidence interval of 91-99% (p<0.001) (Figure 3).

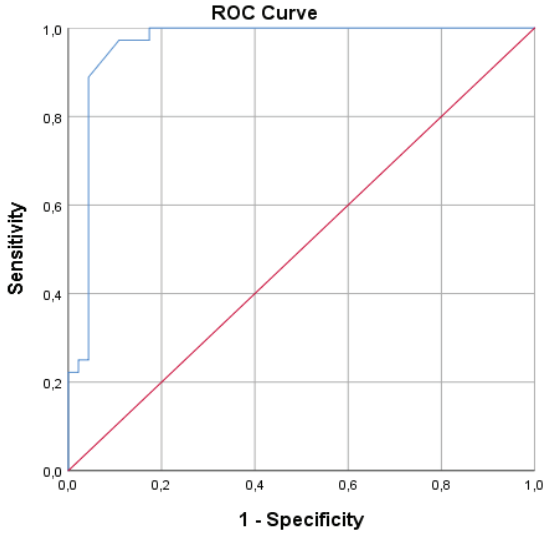


Figure 3: Area under the ROC curve

PI values of patients with BMI ≥ 30 and BMI < 30 at different time periods are presented in Table 3. No statistically significant difference was observed in the PI 0 value between the two groups. However, the PI 10, PI 20, and PI 30 values were significantly lower in patients with BMI ≥ 30 compared to those with BMI < 30 (p = 0.001, p < 0.001, p < 0.001, respectively).

Table 3. Comparison of PI values in patients with BMI ≥30 and BMI<30.

	BMI<30 (n=67)	BMI>30 (n=15)	p
PI 0	2.17±0.65	1.86±0.86	0.604
PI 10	2.30±0.80	1.46±0.73	<0.001
PI 20	2.32±0.81	1.24±0.38	<0.001
PI 20	2.46±0.85	0.85±0.14	<0.001

PI: Perfusion Index BMI: Body Mass Index (ıt is presented Mean±SD)

Discussion

The aim of this study was to investigate the effect of different patient positions and BMI on the PI during the intraoperative period. Initial findings showed that patients in Group 1 had statistically higher PI values after the induction of anesthesia (Figure 1). No significant difference in PI values was observed between the groups at the 0-minute time point before surgery. However, PI values measured at 10, 20, and 30 minutes were significantly higher in Group 1 compared to Groups 2 and 3. The PI provides valuable information regarding changes in organ perfusion, intraoperative fluid status, arterial blood pressure, and systemic hypoxia [9-10]. Consequently, we observed higher PI values in Group 1 patients, likely due to the change in patient positioning compared to the other groups.

In our study, as shown in Figure 2, the PI was lower in patients with a BMI ≥ 25. Considering the variable nature of the PI, we examined its relative variability using the Youden index, with a BMI cut-off of ≥25, to monitor changes in PI in overweight individuals. It was observed that a BMI ≥ 25 had an inverse effect on the relative variability of the PI (Table 3 - Figure 3).

In a study by Smith et al. [11], patients were positioned sitting after anesthesia induction, and a decrease in systemic blood pressure and PI values was observed within the first few minutes of positioning. It was suggested that a decrease in blood volume in the intrathoracic region might explain these changes. In patients placed in the supine position, increased intrathoracic pressure was thought to contribute to changes in PI by reducing cardiac index and blood flow. Similarly, in a study by Tapar et al. [12], the PI was highest in the Trendelenburg position, and, consistent with our findings, PI values were observed to be higher in patients operated in the prone position compared to those in the sitting or supine positions.

Obesity prevalence has been rising globally, with rates now reaching 35-42% [13]. Obesity triggers a cascade of events that predispose individuals to the development of high-flow heart failure. Symptoms of high-flow heart failure progress due to increased diastolic pressure and consequently increased intravascular volume [14]. In the early stages of obesity, patients may experience conditions such as diastolic dysfunction, atrial dilation, and increased cardiac output [15-16]. Our study also demonstrated that PI values decreased more significantly in obese individuals compared to non-obese individuals.

Limitations of our study include the exclusion of different types of surgeries and surgical procedures. Additionally, the relatively small sample size and the single-center design of the study may influence the results. Future studies may benefit from examining the relative change in PI in morbidly obese patients, as this could provide valuable insights into intraoperative management.

In conclusion, the PI was lower in patients with a BMI ≥ 25, and the relative change in PI was negatively correlated. The area under the curve (AUC) indicated that a BMI ≥ 25 negatively affected the relative variability of PI. It was observed that the PI was higher in the prone position compared to the supine and sitting positions. Additionally, the relative change in PI had a negative effect in individuals with a BMI ≥ 25. These results highlight the importance of monitoring PI in obese and overweight individuals with BMI above normal.

Ethical Approval

This study is approved by Amasya University Institution's Ethics Committee (2023000046-1).

Conflict of Interest

The authors have no conflict of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Authors Contribution

HTD conducted the study, inputted and analysed the data, and wrote the manuscript. MK, MK, ST and FK conducted the study, collected the data, and performed follow-ups. MK. HTD and ST,designed the study. OÖK Conducted the study, interpreted the data, and revised the manuscript. All the authors have read and approved the final version of the manuscript. All authors contributed equally to the manuscript and have read and approved the final version.

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