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Can the perfusion index predict spinal anesthesia-induced hypotension in geriatric patients?

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Abstract

Spinal anesthesia patients have a risk of hypotension as a result of decreased vascular tonus and venous pooling. Especially elderly patients may not tolerate this condition. Therefore, it is important to predict hypotension in elderly patients and to take precautions. In our study, the ability of the basal perfusion index (PI) to predict the incidence of hypotension in geriatric patients was tested. 80 patients over 65 years of age who were operated under spinal anesthesia were included in this study. Preoperative PI values, preoperative and after anesthesia systolic arterial pressure values were compared. High PI measurements of the patients can be interpreted as an indication that systolic blood pressure measurements will be low after spinal anesthesia ($r = -0.155$ $p = 0.041$). However, it was concluded that PI value is not a useful test for routine use in predicting hypotension. Although PI may be affected by fluid status, vascular tone or sympathetic activities of patients, with preoperative use of PI, A correlation between PI and systolic blood pressure may be guiding in perioperative follow-up. In fact, complications can be reduced by considering the signs of PI.

Keywords: Spinal anesthesia, hypotension, perfusion index.

Introduction

Elderly patients need more surgery because of increased comorbidities. Spinal anesthesia is frequently preferred in these surgical procedures. However, spinal anesthesia provides less hemodynamic stability than general anesthesia and the risk of developing hypotension is not at all low [1, 2].

The development of hypotension following spinal anesthesia is observed as a result of decreased vascular tone, peripheral blood pooling and decreased stroke volume. The basal vascular tone and fluid status of patients may affect the risk of hypotension development [1].

Geriatric patients may have difficulty in tolerating the negative effects of hypotension and this is associated with increased complications [3,4].

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According to the study by Carpenter et al. Old age is one of the main risk factors for the development of hypotension during spinal anesthesia [5].

The perfusion index (PI) is a ratio calculated with pulsatile light absorption over continuous light absorption and gives information about the vascular tone and volume status with the data obtained from a pulse oximeter which is a part of standard anesthesia monitorization. This new information technology was used in the follow-up of patients' prognosis and fluid response in trauma or septic patients or even used for estimating the success of regional anesthesia [6, 7].

The aim of our study was to test the power of the basal PI values of geriatric patients to predict hypotension after spinal anesthesia.

Materials and Methods

Patient selection and study design

All types of orthopedic and general surgery operations to be operated with spinal anesthesia were included in the study group.

Our study was carried out in the operating rooms of a university hospital. For this study, diabetes mellitus, peripheral vascular diseases, obesity and uncontrolled hypertension, which may affect the peripheral vascular response, were cited as exclusion criteria. In addition, patients with known cardiac diseases, atrial fibrillation, and ejection fraction <50%, which could affect cardiac output, were excluded from the study due to exclude low cardiac output related hypotension.

After the appropriate fasting period, patients were taken to the operation room and standardized monitoring which included heart rate (HR), oxygen saturation (Spo2), noninvasive blood pressure systolic and diastolic (SAP_1 and DAP_1), and mean arterial blood pressure (MAP_1) monitoring were performed. In addition, PI values were obtained from patients with pulse oximetry (Masimo Rainbow Platform; Masimo Corp., Irvine, CA, USA).

Spinal anesthesia was applied to all patients at the target block-level T10 and below. Blood pressure values of the patients after spinal anesthesia were recorded in 30seconds intervals in the first 10 minutes. The lowest systolic arterial tension in the first 10 minutes was recorded as the value after anesthesia (SAP_2). Intermittent bolus doses of ephedrine were administered to patients who developed hypotension, and after that point, their values were not recorded for the study.

Patients with a systolic arterial pressure reduction of 30% or more were accepted as hypotensive. Correlation between the obtained data, PI, and the frequency of hypotension due to spinal anesthesia were examined. Although the definition of hypotension is different in some studies, 30% SAP change was used to evaluating systolic arterial hypotension according to a reference study [9].

Statistical analysis

IBM SPSS 18.0 (IBM Corp. IBM SPSS Statistics for Windows, Version 18.0. Armonk, NY: IBM Corp.) was used for analysis. In the study, the Kolmogorov-Smirnov normality test was carried out to examine the distribution of the measured values. Independent sample t test was used to compare fasting times of patients with high and low PI. Spearman's Correlation Analysis was performed to investigate the relationship between PI and preoperative Systolic Tension and after spinal anesthesia Systolic Tension measurements. ROC (Receiver Operating Characteristic) analysis was performed in order to investigate diagnostic capabilities between preoperative systolic blood pressure measurements and PI. Correlation analysis was performed to examine the relationship between preoperative measurements of age, heart rate and systolic tension measurements according to PI cut-off point. In the study, p values less than 0.05 were considered statistically significant.

Ethics committee approval

Approval was obtained from the local ethics committee of a university for this study. After the approval of the local ethics committee (2017-KAEK-189_2019.02.28_1), patients who applied to the anesthesia polyclinic for preoperative examination were informed about the study. Patients who agreed to participate in the study and signed the informed consent form were included in the study.

Results

Eighty patients over the age of 65 years who underwent orthopedic operations under spinal anesthesia were included in the study. The mean PI of all patients was 3.25 ± 1.74. The minimum PI was 0.6 and the maximum PI was 8. The average preoperative fasting time was 7.57±2.7 hours in patients with high baseline PI, which was not different from that in patients with low baseline PI, 7.31 ±2.2 h (P = 0.57).

The Relationships between age, heart rate and systolic blood pressure changes:

The mean age of the patients included in the study was 73.8 ± 5.47 (minimum 66-maximum 87), mean heart rates were 80.52 ± 13.47 (min. 54- max. 116), and mean systolic blood pressure decrease was 19.2 ± 11.19 (min. + 18.5% – max.-40%). Descriptive statistics of the demographic features are presented in Table 1. When the correlation between age, preoperative heart rates and decrease in systolic blood pressure after spinal anesthesia was examined, there was a significant relationship between age and blood pressure decrease (p =0.001). Among all elderly patients, more systolic blood pressure decreases were observed in older patients. There was no relationship between heart rate and systolic blood pressure changes (p= 0.610). Correlation between age, heart rate and systolic blood pressure changes shown in Table 1. Also, a ROC analysis was performed between the age and development of hypotension. The area under the curve was 0.846 (sd:0.063 CI 95%, sensitivity 0.75 and1-specificity 0.70) and this value was significant. The 74.5 was found to be cut-off in detecting hypotension. (p=0.001). Positive predictive value (PPV) was 78 and negative predictive value (NPV) was 66. The risk of developing hypotension was higher in patients older than 74.5 years.

Table 1. Correlation between age, heart rate and systolic blood pressure changes.

	Mean values		Age	Heart Rate
Heart Rate	80.52 ± 13.47	r	- 0.124	
		p	0.271	
SAP Change %	19.2 ± 11.19	r	0.848	-0.058
		p	0.001	0.610

Heart Rate; preoperative heart rate, SAP Change; percentage of systolic blood pressure changes before and after anesthesia.

Investigation of Relation between Systolic Blood Pressure and Basal Perfusion Index Values:

There is a negative and very weak correlation between post-spinal anesthesia Systolic Blood Pressure Measurements and PI measurements. High PI measurements of the patients can be interpreted as an indication that systolic blood pressure measurements will be low after spinal anesthesia (r = -0.155, p = 0.041).In all patient groups, it can be seen that there is a weak positive correlation between preoperative systolic blood pressure measurements and PI measurements.

High PI measurements of patients can be interpreted as an indication that preoperative systolic blood pressure measurements will be high (r = 0.291, p = 0.032). In all patient groups, there was a positive and moderately strong significant relationship between SAP_1 measurements and SAP_2 measurements (r = 0.499, p = 0.001). The relationship between SAP_1, SAP_2, and PI in patients is shown in Table 2.

Table 2. The relationship between SAP_1, SAP_2 and PI in patients is shown in Table 2

	Mean values		SAP_1	Basal PI
Basal PI	3.25 ± 1.74	r	0.291	
		p	0.032	
SAP_2	98.60 ± 11.93	r	0.499	-0.155
		p	0.001	0.041

SAP_1: preoperative systolic arterial pressure, SAP_2: Post spinal anesthesia systolic arterial pressure, Basal PI: Preoperative basal peripheral perfusion index. The mean SAP 1 was 123.17 ± 15.20.

Relationship between preoperative Systolic Blood Pressure and Hypotension:

According to the hypotension development status of the patients, it was found to be AUC: 0.734 under the ROC curve and it was significant. Calculated sensitivity and specificity values were found to be closest to the optimum cut-off points (p = 0.004, p <0.05). More frequently hypotension development (> 30% reduction in SAP) observed in patients with high SAP 1 values. The value of 143 mmHg SAP_1 was determined as the most suitable cut-off point with 0,88 sensitivity and 0,94 1-specificity. PPV was 82 and NPV was 72 Figure1.

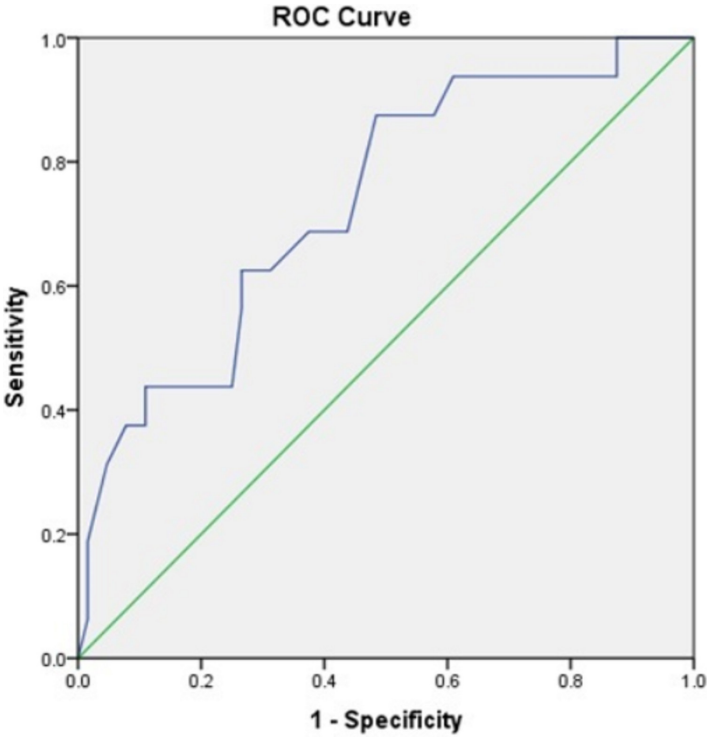

Figure 1. Diagonal segments are produced by ties

Relationship between basal Peripheral Perfusion Index and Hypotension development incidence:

Although there is a weak correlation between high PI value and SAP_2 values (r = -0.155, p = 0.041) when the basal PI and hypotension incidence interpreted with ROC analysis, the CI of the test was 95% AUC 0.655 and p-value was 0.056. We found that the basal PI is not a useful test to predict hypotension.

Discussion

Spinal anesthesia-induced hypotension is mainly a result of decreased systemic vascular resistance due to blockade of preganglionic sympathetic fibers. Hypotensive patients are at risk of decreased coronary and cerebral blood flow. [2, 4, 8].

Spinal anesthesia also induces blood pooling in blocked areas of the body, leading to reductions in cardiac output and SAP. Therefore, preoperative sympathetic activity and preoperative volume status are known to affect the degree of such hypotension [1]. However, the preoperative peripheral vascular tone may also have an influence on this hypotension [4]. The PI gives information about the vascular tone and the volume state via calculating pulsatile and non-pulsatile flow ratio [10, 11].

In a study conducted in pregnant women, more hypotension was observed in patients with a high basal PI [8]. In this study, pregnant women with low peripheral vascular tone had higher peripheral PI values and therefore had a higher risk of developing hypotension in patients with low vascular tone. In the same study, it was emphasized that there was a decrease in PI values in patients after spinal anesthesia and this was due to venous pooling and a decrease in preload. This has been explained as the fluid state is also an important factor in the PI. In our study similar to the previous study, more hypotension incidence was observed in elderly patients with high basal PI. However, the predictive power was not sufficient to support the routine use of this test. As the p-value was close to the significant value that could be considered acceptable, it suggested that it would be beneficial to re-evaluate this situation with more patients. Besides, there was also a positive correlation between baseline PI and preoperative blood pressure values. Blood pressure change rates may be expected to be higher in patients with high preoperative systolic blood pressure. Consistently, preoperative systolic blood pressure was found to be at an acceptable test level with AUC 0.734 according to ROC analysis to predict hypotension (more than 30 percent change in systolic arterial pressure) (Figure 1).

An important result in our study was the insignificant power of the baseline PI in predicting hypotension. Although there is a significant relationship between the blood pressure values before and after the procedure separately, it was not sufficient to use this value as a predictive test. When we evaluate predictive power according to the size of the area under the curve in the ROC analysis, the strength of the statistical meaning can be accepted as moderate since the AUC 0.655. If the area under this curve was higher than 0.8, the test could be interpreted as a more powerful test. However, the result of the analysis was found to be statistically insignificant. This result means that this non-invasive and easily applicable test can not be used to predict hypertension in geriatric patients. But it is useful to be informative [12].

Ginosar and colleagues have found that an increase in PI is an earlier indicator of sympathectomy in epidural anesthesia than a rise in skin temperature [13]. In another study conducted with epidural anesthesia, it was found that the decrease in PI was an effective indicator for accidental intravascular injection of an epinephrine-containing test dose [14]. Yokose et al. found that the basal PI in pregnant women was elevated in hypotensive patients but not as significant as baseline heart rate in predicting hypotension. No such correlation was observed in our study [15].

Nakasuji et al. reported that hypotension in geriatric patients was not a result of stroke volume reduction but was a result of decreased peripheral vascular resistance. Therefore, stroke volume changes were not considered in the patients in our study. This point may be a limitation for our study because it is more important to predict hypotension in geriatric patients because these patients have many comorbidities that make it difficult to tolerate hypotension. However, our patients were highly selected to focus only on the PI and blood pressure changes [16]. Besides the vascular tone, PI also provides information about the patient's volume status and sympathetic activity [10]. Toyama et al. performed a 500 ml colloid solution preoperatively to close the fluid gap in cesarean patients in a study examining the PI and explained the high PI with vascular tone. However, it is not known how much stress factor affects PI in a stressful operation such as cesarean section. In addition, peripheral vascular tone changes due to hypertension or autonomic neuropathies and volume reduction due to nutritional deficiencies can be seen more frequently in geriatric patients [1] . Beside to vascular and fluid problems, known or unknown decreased stroke volume can be observed in these patients. The excess of these factors make geriatric patients more susceptible to anesthesia induced hypotension [2]. Even short-term hypotension is known to negatively affect outcomes in geriatric patients [16]. As a result of all factors, regardless of volume status, vascular tonus or any outcome affecting PI more hypotension was observed in geriatric patients or cesarean patients who had high PI.

A negative aspect of the PI is that it gives more accuracy in patients with high peripheral perfusion. However, it has been used successfully to detect fluid status in intensive care and neonates. Altogether, it can be used as a useful tool in the prediction of hypotension in all patients.

PI is measured from data obtained by pulse oximetry which is part of the standard anesthesia monitoring system. This method, which is non-invasive, low-cost, and easy to apply, can be used routinely in all patients undergoing spinal anesthesia.

Conclusion

Regardless of the factor affecting the PI, a high PI is associated with an increased risk of hypotension after spinal anesthesia in geriatric patients. It is even more important to predict hypotension due to increased comorbidities in geriatric patients. Although PI use does not have sufficient predictive power as a test in predicting hypotension, it is known to be associated with the incidence of hypotension. Since its use is very easy and informative, complications can be reduced by taking precautionary measures with regular perioperative PI use.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
All authors declare no financial support.

Ethical approval
Approval was obtained from the local ethics committee of a university for this study. After the approval of the local ethics committee (2017-KAEK-189_2019.02.28_1)

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