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The efficacy of inferior vena cava diameter, perfusion index and pleth variability index on predicting hypotension in spinal anesthesia

Tolga Kansiz[a], Hilal Ayoglu[a], Bengu Gulhan Aydin[a,*], Rahsan Dilek Okyay[a], Gamze Kucukosman[a], Huseyin Oztoprak[a], Ozcan Piskin[a]

[a]*Bulent Ecevit University, Faculty of Medicine, Department of Anesthesiology and Reanimation, Zonguldak, Türkiye*

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Abstract

Aim: One of the most common side effects of spinal anesthesia (SA) is hypotension. The aim of the study was to evaluate the efficacay of inferior vena cava (IVC) diameter measurements, perfusion index (PI) and pleth variability index (PVI) values in determining the risk of developing hypotension after SA.

Materials and Methods: This study was conducted on 81 patients who underwent transurethral prostatectomy. Before administration of SA, PI and PVI values, IVC diameters (IVCmin: during inspiration and IVCmax: during expiration) and IVC collapsibility index (IVCCI) values and non-invasive blood pressure were recorded. Patients with a baseline systolic arterial pressure reduction rate of ≥25% were determined as the group developing hypotension. IVC diameter measurements were measured immediately after SA then 5 min, and at the end of the operation. The heart rate, mean arterial pressure, PI and PVI values were recorded at regular intervals.

Results: Hypotension occured in 32 patients (39.5%). In the hypotensive group, IVCmax and IVCmin values were observed lower and IVCCI values higher. The optimal threshold value of IVCmin was ≤0.99 and threshold value of IVCCI was >%44.5 for predicting hypotension after SA.

Conclusion: While IVCmin and IVCCI values were effective in determining hypotension risk after SA, PI and PVI values were not. To predict hypotension by IVC diameter measurements after SA will allow a more effective intervention and avoid hypotension.

Introduction

Hypotension occurs due to a decrease in cardiac output and systemic vascular resistance as one complication of spinal anesthesia (SA). As a result of sympathetic blockade and pooling of blood in blockaded areas, hypotension may cause serious risk, especially in elderly patients with high cardiovascular disease incidences and undergoing transurethral prostate resection (TURP) [1,2]. Peripheral vasomotor tonus, sensory block level at or above T5, preoperative volume status, comorbidities, physical status, preoperative medications, and age more than 40 years may affect hypotension after SA [3]. Many interventions (fluid preloading/co-loading and prophylactic vasopressors) can be used to prevent hypotension by predicting patients previously who will develop hypotension. It is finding a method that accurately and quickly predicts hypotension development after SA will avoid adverse effects. Some studies have shown a correlation between right atrial pressure, circulating blood volume, and inferior vena cava (IVC) diameters [4-5]. Perfusion index (PI) is a noninvasive measurement parameter of peripheral perfusion reflecting the vasomotor tonus [6]. Pleth Variability Index (PVI) which is calculated by measuring the dynamic changes in the perfusion index is an algorithm predicting the fluid response [7]. In our study, we aimed to assess the inferior vena cava (IVC) diameters, PI, and PVI on predicting hypotension in patients who underwent TURP operation under SA. Our secondary goal was to evaluate the cut-off points of the measurements to predict hypotension after SA.

Material and Methods

Clinical Research Ethics Committee Approval (Meeting protocol no: 2016-99-24/08, Date: 24.08.2016) was obtained for this study. Ninety patients over 40 years of age

*Corresponding author:
Email address: bengukoksal@gmail.com (Bengu Gulhan Aydin)

with American Society of Anesthesiologist (ASA) physical status classes I-III and who were scheduled for elective TURP operation under SA were included in the study after obtaining informed consent forms. Exclusion criteria were BMI more than 30 kg m-2, absolute or relative contraindications to SA, ejection fraction <40%, presence of intra-abdominal mass-acid, increased intra-abdominal pressure, autonomous nervous system disease, intracardiac shunt, peripheral vascular disease, diabetes mellitus, long-term oral vasoactive drug use, aortic stenosis, arrhythmia, neurological sequelae and presence of psychiatric problems were accepted as the exclusion criteria. The patients' demographic data (age, height, body mass index [BMI]) and ASA risk groups, the presence of heart diseases and hypertension in the anamnesis were noted. In all cases without premedication, vascular access was opened with a 20-gauge cannula, and 10 mL kg-1 h-1 saline infusion was started after administration of SA. No fluid preload was infused to any patient before SA. Standard monitors such as electrocardiogram, noninvasive blood pressure, and pulse oximeter were attached to the patient. Baseline systolic [SAP], diastolic [DAP], and mean arterial pressures [MAP]), oxygen saturation (SpO2) and heart rate (HR) were noted. Masimo Root® (Masimo Corp., Irvine, CA, USA) probe was placed on the left-hand index fingers of the patients for the measurement of PVI and PI values, and baseline values were noted. The researcher to perform the IVC measurement received adequate training in this field in the radiology department before starting the study. The inferior vena cava diameter (cm) ([IVCmin] during inspiration and [IVCmax] during expiration) and the inferior vena cava collapsibility index (IVCCI) values (%) of the patients before the operation were measured and recorded with the Esaote® ultrasound device. After obtaining 4-chamber position from the subxiphoid area when the patient was in the supine position, the probe was placed in the vertical position to identify the right atrium and right ventricle, and the IVC became visible with the right atrium as the probe was advanced into the spine. To demonstrate the association of IVC with hepatic veins, the image was followed downwards, and after the IVC was visualized, the measurements were performed at 2 cm from the junction with the hepatic vein. Three scans were performed for consistent IVC measurements. The mean value of three scans was taken for measurements. All evaluations were performed in M-mode with a low frequency (3.5-5 MHz) convex probe. IVCCI was calculated and recorded by (IVCmax-IVCmin)/IVCmax formula at the points where the diameter was the largest and the smallest (maximum-minimum) during expiration-inspiration. Baseline IVC measurements were noted. In all patients, a lumbar puncture was performed under aseptic conditions and in a sitting position from the L3-4 vertebral space. Infiltration anesthesia was performed on the skin and subcutaneously with 2 mL of 2% lidocaine. A dose of 12 to 14 mg of 0.5% hyperbaric bupivacaine (12 mg in patients with a height of <175 cm, and 14 mg in patients with a height of ≥175 cm) was injected through a 25-gauge Quincke spinal needle with the aim of the spinal blockade. Patients were taken to the supine position after injection without waiting. The air blower heater was used in all patients during the operation. Hemodynamic data [SAP, DAP, HR, MAP, SpO2], PI, and PVI values were recorded during the operation at every 5th minute in the first 1 hour, and then at every 15th minute after SA. SAP pressure reduction rate (baseline SAP-smallest SAP)/ baseline SAP) ≥25% in patients was considered as the presence of hypotension. This definition was based on previous studies [8]. Patients were then divided into two groups depending on whether they developed hypotension (Group H) or did not (Group O) after SA. IVC diameter measurements were repeated immediately after SA, then 5 min, and at the end of the operation. Patients were placed in the lithotomy position immediately after the IVC measurements at the 5th minute. During operation, when systolic blood pressure decreased below 90 mmHg, iv 5 mg ephedrine was administered, and when heart rate fell below 50/min, iv 0.5 mg atropine was administered and noted. Oxygen was not administered unless arterial oxyhemoglobin saturation obtained from pulse oximetry fell below 95%. The intraoperative block levels of the patients were evaluated with a pinprick test with 5 min intervals in the 1st hour, and then at 15 min intervals. The maximum level of sensory block was recorded. The amount of fluid administered intraoperatively, and the amount of irrigation fluid used, operation time, amount of prostate removed during surgery, and patients who were administered ephedrine and atropine were recorded. ASA risk scores, operation times, prostate amounts, administered fluid amounts, irrigation fluids, maximum block levels, history of hypertension and heart disease, baseline hemodynamic data (SAP, DAP, MAP, HR), number of patients who were administered ephedrine and atropine, baseline measurements of IVC, PI and PVI values of the cases developing (Group H) and not developing (Group O) hypotension were compared.

Statistical analysis

The data were evaluated with SPSS 19.0 (SPSS Inc., Chicago, IL, USA) program. Descriptive statistics included mean±standart deviation for continuous variables as well as frequencies and percentages for nominal and discrete variables. The conformity of numerical variables to normal distribution was examined with the Shapiro-Wilk test. For the comparison of groups, Mann-Whitney U Test was used for means and Chi-square test was used for discrete variables. Logistic regression analysis was used in the determination of the risk factors. A Receiver Operating Characteristic (ROC) analysis was performed to find the best cut-off points. Taking into consideration the results of previous studies [9] with an alpha error of 0.05 and a power of 80%, we calculated the sample size as 90 patients with GPower (3.1.9.2) program. Results of statistical tests were evaluated with 95% confidence interval and the statistical significance level was defined as $p<0.05$.

Results

Of the 90 patients who underwent transurethral resection of the prostate with SA, only 81 patients were included in the study due to the absence of the IVC measurements in 9 patients. There was a significant difference in surgical duration, prostate size, maximum blockade levels, volumes

Table 1. Comparison of patient characteristics and clinical data.

	Hypotension		
	Group H (+) (n=32)	Group O (-) (n=49)	P
Age (years)	68 ± 8.5	65 ± 8.5	0.137
Height (cm)	166.5 ± 7.2	169.1 ± 6.5	0.102
BMI (kg/m2)	28.1 ± 3.9	27.5 ± 3.8	0.467
ASA (II/III)	10/22	22/27	0.319
Operation time (min)	67.2 ± 34.4	51.4 ± 28.5	0.025
Prostate amount (g)	48.3 ± 31.7	34.0 ± 19.0	0.036
Administered fluid amount (mL)	893.7 ± 433.9	695.9 ± 319.3	0.025
Irrigation fluid (mL)	17937.5 ± 12574.7	13765.3 ± 9607.9	0.115
Maximum block level (T4/T6/T8/T10/T12)	6/2/9/15/0	0/2/9/31/7	0.001
HT (+/-)	25/7	37/12	0.997
HD (+/-)	16/16	20/29	0.559
MAP (mmHg)*	111.4 ± 8.9	105.2 ± 10.7	0.009
SAP (mmHg)*	159.8 ± 14.9	149.1 ± 16.6	0.004
HR (beat/min)*	79.8 ± 20.4	80.8 ± 14.2	0.250
Use of ephedrine (+/-)	11/21	1/48	0.001
Use of atropine (+/-)	6/26	3/46	0.163
IVCCI (%)*	51 ± 14	46 ± 14	0.053
IVCmax (cm)*	1.66 ± 0.23	1.74 ± 0.28	0.118
IVCmin (cm)*	0.83 ± 0.32	0.95 ± 0.31	0.028
PI*	2.89 ± 1.8	2.82 ± 2.09	0.685
PVI*	19.7 ± 9.4	16.7 ± 7.3	0.071

BMI: Body Mass Index, HT: Hypertension, HD: Heart Disease, MAP: Mean Arterial Pressure, SAP: Systolic Arterial Pressure, HR: Heart Rate, IVCmin: Inferior Vena Cava Inspiration Diameter, IVCmax: Inferior Vena Cava Expiration Diameter, IVCCI: Inferior Vena Cava Collapsibility Index, PI: Perfusion Index, PVI: Pleth Variability Index
*Baseline Values.

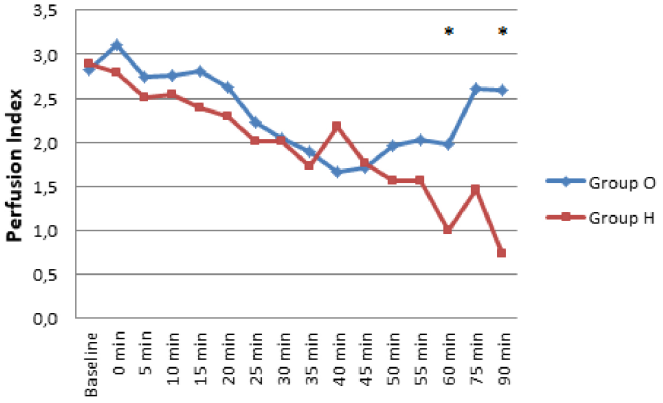

Figure 1. Comparison of PI Values

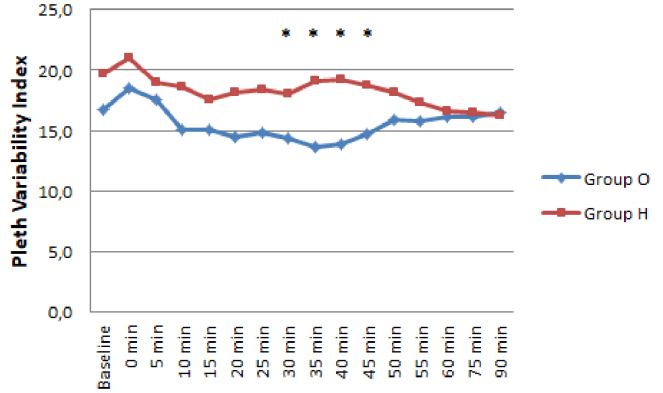

Figure 2. Comparison of PVI Values

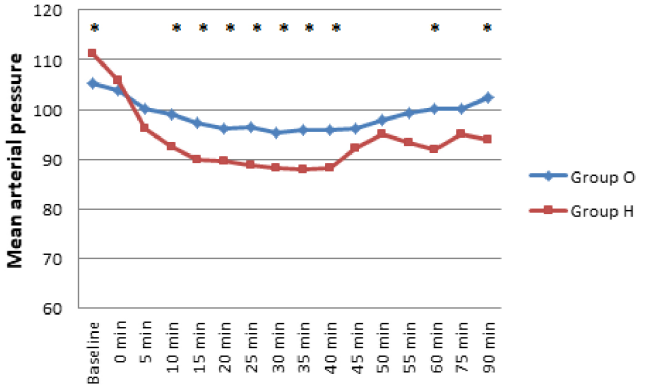

Figure 3. Comparison of MAP Values

of intraoperative fluid, use of ephedrine, baseline values of IVCmin, MAP and SAP between the patients developing (Group H, n = 32) and the patients not developing (Group O, n = 49) hypotension. However, there was no significant difference in age, height, BMI, the ASA scores, irrigation fluids, history of hypertension and heart disease, baseline IVCmax, IVCCI, PI, PVI, HR, the use of atropine between the groups (p>0.05) (Table 1).

ROC curve analysis showed that baseline IVCmin had a sensitivity of 75%, a specificity of 53.06, and an accuracy of 95% to predict hypotension after SA at a cut-off point ≤ 0.99. The AUC was 0.64 (CI 0.53 to 0.74, p=0.01). Baseline IVCCI had a sensitivity of 71.87%, a specificity of 55.10, and an accuracy of 95% to predict hypotension after SA at a cut-off point more than more than 0.44 (or 44%) The AUC was 0.62 (CI 0.51 to 0.73, p = 0.04). IVCmax initial cut-off point was ≤ 1.67. AUC for baseline IVCmax was 0.60 (CI 0.48 to 0.71, p=0.10). PI initial cut-off point was >3.7. AUC for baseline PI was 0.52 (CI 0.41 to 0.63, p=0.68). PVI initial cut-off point was ≤ 1.67. AUC for baseline PVI was 0.61 (CI 0.50 to 0.72, p= 0.06). (Table 2)

Multivariate logistic regression analysis showed that PVI was the most significant predictor of hypotension (95% CI 1.02 to 1.25, P=0.021), baseline PI and IVC measaurements values were not a good predictor of hypotension after SA (Table 3). All IVCmin values were lower in the hypotensive group (p<0.05). IVCmax values were lower in the hypotensive group at 0min and 5min (p<0.05). IVCCI values were not the difference between the groups after SA (Table 4).

PI values were lower at the 60th and 90th minutes in group H (p<0.05) (Graphic 1).

PVI values were higher at 30th, 35th, 40th and 45th min-

Table 2. Evaluation of baseline vital parameters, PI and PVI values, IVC measurements, irrigation fluids, administered fluid amounts, operation times, prostate amounts with ROC analysis.

	Cut-off Point	AUC	%95 CI	Sensitivity	Specificity	PPV	NPV	p
MAP* (mmHg)	> 99	0.657	0.54 – 0.75	96.87	28.57	47.0	93.3	0.013
SAP* (mmHg)	> 143	0.679	0.56 – 0.77	90.62	42.86	50.9	87.5	0.004
DAP* (mmHg)	> 74	0.585	0.47 – 0.69	96.87	18.37	43.7	90.0	0.197
HR* (beat/min)	≤ 82	0.576	0.46 – 0.68	75.00	46.94	48	74.2	0.238
PI*	> 3.7	0.527	0.41 – 0.63	34.38	79.59	52.4	65	0.685
PVI*	> 18	0.619	0.50 – 0.72	50.00	75.51	57.1	69.8	0.066
IVCmin* (cm)	≤ 0.99	0.644	0.53 – 0.74	75.00	53.06	51.1	76.5	0.018
IVCmax* (cm)	≤ 1.67	0.603	0.48 – 0.71	53.13	67.35	51.5	68.8	0.104
IVCCI* (%)	> 44.5	0.628	0.51 – 0.73	71.87	55.10	51.1	75.0	0.047
Operation time (min)	> 52	0.648	0.53 – 0.75	62.50	67.35	55.6	73.3	0.020
Administered fluid amount (mL)	> 400	0.647	0.53 – 0.75	93.75	28.57	46.2	87.5	0.021
Prostate amount (g)	> 35	0.638	0.52 – 0.74	59.38	63.27	51.4	70.5	0.031

MAP: Mean Arterial Pressure, SAP: Systolic Arterial Pressure, DAP: Diastolic Arterial Pressure, HR: Heart Rate, IVCmin: Inferior Vena Cava Inspiration Diameter, IVCmax: Inferior Vena Cava Expiration Diameter, IVCCI: Inferior Vena Cava Collapsibility Index, PI: Perfusion Index, PVI: Pleth Variability Index, AUC: Area Under the ROC Curve, CI: Confidence Interval, PPV: Positive Predictive Value, NPV: Negative Predictive Value * Baseline Values.

Table 3. Multivariate logistic regression for prediction of hypotension after spinal anesthesia.

	Odds ratio	%95 CI	p
Age (years)	1.053	0.98-1.14	0.180
BMI (kg/m2)	0.997	0.93-1.07	0.942
MAP*	1.296	0.64 – 2.61	0.469
SAP*	0.967	0.76– 1.22	0.784
DAP*	0.853	0.53– 1.37	0.513
HR* (beat/min)	0.980	0.93 – 1.02	0.339
PI*	1.036	0.77 – 1.38	0.813
PVI*	1.130	1.02 – 1.25	0.021
IVCmin*	0.001	0 – 88.32	0.228
IVCmax*	16.693	0.03 – 11029.80	0.396
IVCCI*	0.886	0.73 – 1.07	0.216
Operation time (min)	0.997	0.92 – 1.07	0.942
Prostate amount (g)	1.013	0.97 – 1.05	0.512
Administered fluid amount (mL)	1.002	0.99 – 1.00	0.384
Irrigation amount	1.000	1.00 – 1.00	0.340

MAP: Mean Arterial Pressure, SAP: Systolic Arterial Pressure, DAP: Diastolic Arterial Pressure, HR: Heart Rate, IVCmin: Inferior Vena Cava Inspiration Diameter, IVCmax: Inferior Vena Cava Expiration Diameter, IVCCI: Inferior Vena Cava Collapsibility Index, PI: Perfusion Index, PVI: Pleth Variability Index, *Baseline Values.

utes in group H ($p<0.05$) (Graphic 2). When MAP values were compared between groups, baseline, 10th, 15th, 20th, 25th, 30th, 35th, 40th, 60th and 90th minutes were significantly different ($p<0.05$) (Graphic 3).

When HR values were compared between groups, no significant difference was found at the time of measurement ($p>0.05$). SpO2 value did not fall below 95 during the operation.

Discussion

In this study, we found that IVCmin and IVCCI values were effective in determining the risk of hypotension after SA, while PI and PVI values were not. We also detected that IVCmin value ≤0.99 cm and IVCCI value> 44.5% were found as the cut-off point for the development of hypotension after SA. The main side effect of SA is hypotension, which is a significant cause of morbidity and mortality [10]. It is a severe source of risk, especially for TURP cases in the older age group [11]. The incidence of critical problems such as cerebral ischemia, myocardial infarction, acute pulmonary edema, acute renal failure, and cardiac

Table 4. Comparison of IVCmin, IVCmax and IVCCI by measurement times after spinal anesthesia between groups.

	Group H	Group O	p
	Mean ± SD	Mean ± SD	
IVCmin (cm)			
0 min	0.84 ± 0.31	0.98 ± 0.32	0.015
5 min	0.83 ± 0.30	0.97 ± 0.312	0.021
End	0.96 ± 0.28	1.08 ± 0.29	0.035
IVCmax (cm)			
0 min	1.66 ± 0.24	1.77 ± 0.23	0.038
5 min	1.65 ± 0.23	1.76 ± 0.24	0.015
End	1.71 ± 0.22	1.81 ± 0.24	0.073
IVCCI (%)			
0 min	49.84 ± 13.58	45.50 ± 14.24	0.073
5 min	50.22 ± 13.23	45.95 ± 14.07	0.086
End	44.15 ± 11.85	40.64 ± 13.08	0.081

Group H: Patients with Hypotension, Group O: Patients without Hypotension, IVCmin: Inferior Vena Cava Inspiration Diameter, IVCmax: Inferior Vena Cava Expiration Diameter, IVCCI: Inferior Vena Cava Collapsibility Index.

arrest, which are associated with sudden hypotension, is more common in the older patients [2, 12]. In a study where the rate of development of hypotension in TURP surgery was evaluated in two different years' intervals, it was shown to be at a rate of 29.4%-40.8% [13]. In our study, hypotension was observed in 39.5% of patients after SA. Prediction of hypotension will allow a faster and more efficient treatment for these cases. SA induced hypotension occurs primarily due to blockage of preganglionic sympathetic fibers and reduced systemic vascular resistance [14]. SA also reduces MAP and cardiac output due to the pooling of blood in blockaded areas. Therefore, preoperative sympathetic activity and intravascular volume are known to affect the degree of hypotension [15-17]. The evaluation of intravascular volume with static parameters such as central venous pressure is an invasive method and might not give accurate results. Recently, it has been reported that dynamic parameters are more recommended especially in evaluating volume status [18]. Low cost, useful, non-invasive dynamic methods, such as PI, PVI values and IVC diameter measurements were used in several studies to predict hypotension by evaluating volume status after SA [7, 19]. IVC is a large vein that changes with its movements and size, respiration and total body fluid. During inspiration, intrapleural pressure becomes negative and causes venous return to the right side of the heart [20]. IVC diameter decreases in inspiration and increases in expiration. Evidence shows that IVC diameter is a reliable indicator of volume status and that respiratory variation is valuable in estimating the ability to respond to fluids [9]. A greater collapsibility of IVC suggest low volume status. The American Society of Echocardiography supports the use of IVC measurement and IVCCI in evaluating volume status [21]. It is recommended to assess IVCCI before SA, especially in older and hypovolemic patients with a high rate of development of hypotension [22]. In our study, it was found that the smallest IVC diameter measured during inspiration was an important indicator for the development of hypotension and that basal IVCmin level $\leq$0.99 cm was the cut-off point for the development of hypotension. When the circulating blood volume decreases in a patient with shock, IVCmin will decrease, and it will become more challenging to measure [23]. IVCCI is known for effective in predicting volume responsiveness. Zhang et al. [9] also showed that preoperative IVCCI measurement was a useful method for predicting hypotension development after general anesthesia induction. In this study, different from our study, a reduction in MAP more than 30% was defined as hypotension, and the cut-off point for IVCCI was reported as 43%, while in our study, this value was similarly found as >44.5%. IVC diameters may vary in sizes among healthy individuals. IVCmax values were evaluated in patients with hypotension (cut-off point 1.8 cm) and shock (7mm, 8±3 mm, <9mm), and it was reported to be lower in patients with hypotension [9, 23, 24]. In our study, the cut-off point for IVCmax was found to be $\leq$ 1.67 for predicting hypotension but no meaningful. In the IVC measurements during the operation, it was observed that IVCmin and IVCmax values were lower, and IVCCI values were higher in the hypotensive group. According to our study results, in the evaluations made before SA, considering that hypotension may develop in cases where IVCCI is above 44.5%, IVCmin $\leq$ 0.99, we recommend fluid preloading and closer monitoring of the patient to prevent possible adverse events. In addition, in our study, it was observed that the sensory block level was higher in group H. Since it is known that the incidence of hypotension increases as the higher sensory block level, we recommend keeping the block level lower in patients with high IVCCI and low IVCmin value to prevent the development of hypotension. Stress and anxiety induce sympathetic activation, which causes peripheral vasoconstriction. The risk of developing hypotension due to vasodilatation in patients undergoing SA after sympathetic activity is higher [7]. In our study, we observed that hypotension developed more frequently in patients with higher baseline MAP and SAP. This may reflect a higher level of sympathetic activity, which we think may be related to possible anxiety before operation. We think that IVC measurements will be useful even in predicting hypotension before SA applications without premedication. The perfusion index reveals the ratio of pulsatile blood flow in peripheral tissue to non-pulsatile blood flow and represents the measurement of peripheral perfusion [25]. It has been reported that PI was useful in assessing peripheral vasomotor tonus, in the detection of central hypovolemia and peripheral vasoconstriction occurring as a result of neurohumoral response [26-28]. Toyama et al. [29] stated that there was a significant correlation between baseline PI value and decrease in systolic and mean arterial pressure during SA for caesarean section. They reported that PI value as a limit value was 3.5 for hypotension occurring as a result of SA (sensitivity: 81%, specificity: 86%, P<0.001) and that the rate of hypotension was higher in patients with high baseline PI value. Dugappa et al. [30] showed that baseline PI >3.5 is associated with a higher incidence of hypotension following SA in caesarean section (sensitivity: 69.84%, specifity: 89.29%%, p<0.001). In our study, although the baseline PI cut-off point was found as 3.7, there was no significant difference between the groups. This discrepancy as attributed to various methodological differences, such as the definition of hypotension, preloading with colloids and method of calculation of baseline PI. We observed that PI values measured at the 60th and 90th min during the intraoperative period were lower in the hypotensive group. We also thought that the cause could be due to the transition from the lithotomy position to the supine position or the decrease in body temperature. PVI is a measurement that calculates respiratory changes in photoplethysmographic wavelengths by data noninvasively collected via a pulse oximeter sensor [31]. PVI has been shown to be highly sensitive and selective in showing the response to fluid replacement and predicton of hypotension in both spontaneous breathing and mechanically ventilated patients [32, 33]. PVI actually reflects the preload, which is not the main determinant of hypotension. Instead, changes in vascular resistance are more important for the development of hypotension. The efficacy of PVI decreases in the evaluation of intravascular volume and in the estimation of the fluid response in spontaneously breathing patients due to larger changes in frequency of breathing tidal volume, and cardiopulmonary interactions [7, 19]. Besides, studies

have been conducted on the possibility that elevations in PVI could predict hypotension on the basis of the increase in stroke volume under SA. Sun et al. [19] investigated the predictability of hypotension by recording the preoperative PVI values in cesarean operations undergoing SA and found that it was not clinically significant. In this study, the threshold value for PVI was found to be 23.5. In our study, although the cut-off point for PVI was found to be >18, there was no significant difference between the groups in terms of PVI. Also PI and PVI can be affected by stress, anxiety and supine position. Stress and anxiety induce sympathetic activation, which reduces PI and PVI by peripheral vasoconstriction. We did not administer sedative premedication to our patients. Therefore, PI and PVI may have been affected by stress and insufficient to predict hypotension. In SA, sympathetic nerve blockage causes vasodilation and increased blood flow in the lower extremities and reduced blood flow in the upper extremities with vasoconstriction in the vessels [19]. For all the reasons mentioned above, PI and PVI may be insufficient in predicting hypotension.

Study limitations

Our study had several limitations. Although stable room temperature was provided in the study, intraoperative body temperatures of patients were not evaluated. It was thought that the lower intraoperative PI values in the hypotensive group were due to factors such as spinal anesthesia, the lithotomy position, irrigation fluids, administered fluid amount, prolongation of operation time and that it may have been caused by vasoconstriction response secondary to decrease in body temperature. Secondly, cardiac output and systemic vascular resistance were not measured in our patients. Arterial and central venous cannulation is not a routine practice for elective TURP without complications.

Conclusions

The determination of the patients who could develop hypotension after spinal block will allow more effective treatment methods to be used in patients, thus reducing the mortality and morbidity rates that may occur due to hypotension after SA. While PI and PVI are not effective in the determination of the risk of developing hypotension after SA, IVC diameter measurements may be beneficial as an easy, low cost, noninvasive and dynamic method.

Ethics approval

Approval for this study was received from Bulent Ecevit University Clinical Research Ethics Committee (Meeting protocol number: 2016-99-24/08, Date: 24.08.2016).

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