AFMN BIOMEDICINE

ORIGINAL ARTICLE

RISK FACTORS FOR SPINAL ANESTHESIA-INDUCED HYPOTENSION DURING ELECTIVE CESAREAN SECTION

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Spinal anesthesia is widely considered the "gold standard" for elective cesarean sections due to its rapid onset and lower risk of complications compared to general anesthesia. However, hypotension is a common adverse effect, influenced by maternal and procedural factors. Despite various preventive measures, predicting hypotension based on patient characteristics remains challenging. This study investigated the relationship between hypotension and variables such as age, BMI, height, preoperative fasting, and hypertension during pregnancy. A retrospective analysis was conducted on 123 patients who underwent elective cesarean section under spinal anesthesia between April and August 2023 at the Clinic of Gynecology and Obstetrics, Novi Sad. Demographic data, anesthetic dose, timing of surgery, and blood pressure trends were collected. Patients were categorized according to delivery time, height, occurrence of hypotension, and history of hypertension. Statistical analyses included Student's t-test, Mann–Whitney U, Shapiro–Wilk, chi-square tests, ANOVA, and correlation analysis. Hypotension occurred in 45.5% of patients. Older age was significantly associated with a higher incidence of hypotension ($p = 0.031$), whereas hypertension during pregnancy correlated with a lower incidence ($p = 0.032$). Height, BMI, and surgery timing had no significant impact on hypotension risk. Taller patients received a larger volume of anesthetic ($p = 0.005$), with a moderate correlation between height and dose ($r_s = 0.427$, $p < 0.001$); however, anesthetic dose was not predictive of hypotension. Most hypotensive events occurred within 10 minutes following spinal anesthesia. In conclusion, hypotension was associated with older age, while hypertension during pregnancy appeared to have a protective effect. No significant associations were found with height, BMI, or fasting duration. These findings highlight the need for individualized monitoring and larger-scale studies to optimize spinal anesthesia management in cesarean delivery.

Keywords: spinal anesthesia, hypotension, cesarean delivery

Submitted: July 9, 2025 **Accepted:** October 16, 2025
Published online: June 12, 2026
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INTRODUCTION

Neuraxial analgesia (spinal, epidural, or combined spinal epidural anesthesia) is the "gold standard" for labor pain relief (1). The choice of anesthetic technique for cesarean delivery is based on the safety and health benefits to the mother and fetus, the experience level of the practitioner, and the availability of drugs and equipment (2). Spinal anesthesia has been favored as the best choice for elective, uncomplicated cesarean deliveries (1,2,3). Compared to epidural anesthesia, spinal anesthesia allows for earlier onset of surgery and requires approximately ten times less anesthetic to achieve a comparable level of anesthesia for a cesarean section (3). It offers better health-related outcomes than general anesthesia, minimizing complications such as failed intubation, failed ventilation, and aspiration of gastric contents; moreover, maternal mortality is significantly reduced when general anesthesia is avoided (2,4). Potential adverse effects common to both spinal and epidural anesthetic techniques include: maternal hypotension, failure to provide adequate anesthesia, post-dural puncture headache (PDPH), which may be associated with meningitis, intracranial hemorrhage, subdural hematoma, itching, and transient neurologic symptoms over the injection site (3,5).

Among the reported side effects, hypotension is the most common, with incidence varying widely across studies, ranging from 7.4% to 74.1% (6). Spinal block-induced sympatholysis causes arterial and venous vasodilatation, leading to a decreased systemic vascular resistance (6,7). The incidence of hypotension may be influenced by a range of environmental and individual factors, including hypovolemia, preoperative hypertension, block level related to vertebral column height, age over 40 years, obesity, and the use of combined general and spinal anesthesia (8,9). Some studies have suggested that anesthetic dosing may be adjusted based on patient characteristics, although this approach remains under ongoing investigation (10). While some anesthetists prefer a fixed dosage regimen, others tailor the anesthetic dose according to patient-specific characteristics such as height, weight, and body mass index (10,11). However, despite their frequent use, these parameters have shown limited reliability in accurately predicting the spread of spinal anesthesia (11,12).

A systematic review by Klöhr et al. revealed significant variability in how spinal anesthesia-induced hypotension is defined. Among 63 studies, they identified 15 different definitions, with the most common being a drop to 80% of baseline systolic arterial pressure (SAP), or a combination of SAP ≤ 100 mmHg and ≤ 80% of baseline (6). Baseline blood pressure is commonly defined as the initial reading obtained upon arrival in the operating room (13). A consensus published in 2018 recommends maintaining SAP at or above 90% of baseline to reduce maternal side effects (14).

Spinal anesthesia-induced hypotension is commonly associated with maternal nausea and vomiting, which may lead to aspiration of gastric contents. In rare cases, it can result in cardiovascular collapse, loss of consciousness, cardiac arrest, and even maternal death (15,16). If prolonged, maternal hypotension can impair uteroplacental blood flow, potentially leading to neonatal acidosis and, in severe cases, neurological injury or intrauterine fetal death (15). However, the extent to which reduced uteroplacental perfusion affects fetal outcomes remains a subject of ongoing debate. Nonetheless, there is a broad consensus on the importance of closely monitoring hemodynamic changes to ensure the well-being of both mother and fetus, as well as the value of implementing preventive measures against hypotension (6,16,17).

In order to prevent the nearly inevitable hypotension and other known side effects associated with spinal anesthesia, a range of strategies has been developed (17, 18). Leg wrapping for venodilation and left lateral tilt can help alleviate aortocaval compression caused by the gravid uterus on the abdominal aorta and inferior vena cava, which has been associated with reduced hemodynamic changes (18,19). Antiemetic prophylaxis is typically administered after clamping the umbilical cord to reduce nausea and vomiting (20). Although intravenous fluid loading has been tested and found to be only marginally effective, IV co-loading (administering fluids in parallel with the spinal block) appears to be the most effective strategy (18). The type of intravenous fluid (crystalloid or colloid) used is not a primary factor causing hypotension, allowing staff to select fluids based on the patient's individual needs while focusing on other contributing factors (21). The use of vasopressors is crucial in managing spinal hypotension, with phenylephrine currently the vasopressor of choice to compensate for arteriolar vasodilation (18,22). The use of a low dose of spinal bupivacaine has been associated with a reduction in maternal side effects. However, careful dose selection is crucial, as insufficient anesthesia can lead to the need for general anesthesia, increasing the risk of maternal and neonatal complications (23).

The aim of this study was to examine the association between risk factors and the occurrence of hypotension in pregnant women who had an elective cesarean section under spinal anesthesia. The following hypotheses were proposed: that pregnant women with shorter body height experience hypotension more frequently during elective cesarean section under spinal anesthesia, that the duration of preoperative fasting affects the occurrence of hypotension during elective cesarean section under spinal anesthesia, and that participants diagnosed with arterial hypertension during pregnancy experience hypotension less frequently during elective cesarean section under spinal anesthesia.

METHODS

Study design

This retrospective study analyzed data from the medical records of pregnant women who underwent elective cesarean section under spinal anesthesia at the Clinic of Gynecology and Obstetrics in Novi Sad between April and August 2023. It included 123 pregnant women whose cesarean deliveries were completed entirely under spinal anesthesia. Cases where surgery was initiated under spinal anesthesia but converted to general anesthesia were excluded. Data were obtained from photocopies of anesthesia records. Demographic data collected included patient age, height, weight, and Body Mass Index (BMI). For each patient, the level of the spine at which the local anesthetic was administered and the total dose given were recorded. Based on the surgical schedule and operation time, patients were grouped by delivery time intervals: 8:00 AM–10:00 AM, 10:00 AM–12:00 PM, and after 12:00 PM. Those operated on later had a longer preoperative fasting period, which was a relevant variable in this study. Anesthesia records were also used to collect data on arterial blood pressure at the time of entering the operating room, as well as the lowest recorded systolic, diastolic, and mean arterial pressure during surgery. For patients who experienced a drop in blood pressure below 90 mmHg, the time elapsed between administration of the local anesthetic and the onset of hypotension was noted. It was also recorded whether the patient had been diagnosed with hypertension during pregnancy. In hypotensive cases, the amounts of phenylephrine and adrenaline administered by the anesthesiologist were documented. Data were compiled in a Microsoft Excel (Office 2019) database. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Clinical Center of Vojvodina (approval number 00-113, issued on 23 June, 2023).

Statistical analysis

All data were analyzed using JASP 0.17.2.1. and IBM® SPSS® Statistics 26. Within the sample of 123 patients, groups were formed based on height: patients taller than 165 cm were classified as the tall group (Group V), while those shorter than 165 cm were classified as Group M. Based on the lowest recorded systolic pressure during cesarean section, patients were divided into hypotensive (Group H), with systolic pressure below 90 mmHg, and normotensive (Group N), with systolic pressure remaining above 90 mmHg throughout the procedure.

Descriptive statistics were used to summarize all demographic data. For continuous variables with one categorical independent variable (with only two levels), Student's *t*-test was used when the Shapiro-Wilk test indicated a normal distribution. If the Shapiro-Wilk test showed deviation from normality, the non-parametric Mann–Whitney U test was applied. The chi-square test (χ^2) was used to assess differences in frequencies of categorical variables. Analysis of Variance (ANOVA) was used when there were three levels of an independent variable, or when there was more than one independent variable. Pearson's linear correlation coefficient (r) was applied for normally distributed continuous variables. When data deviated from a normal distribution, Spearman's rank correlation (r_s) was used instead. A p-value < 0.05 was considered statistically significant.

RESULTS

The study included 123 female patients. Group V (patients whose height was greater than 165 cm) consisted of 78 participants, while Group M (patients whose height was less than 165 cm) included 45 participants. In the group of pregnant women who had a blood pressure lower than 90 mmHg during surgery (Group H), there were 56 participants, while in 67 participants, the systolic blood pressure during surgery did not fall below 90 mmHg (Group N).

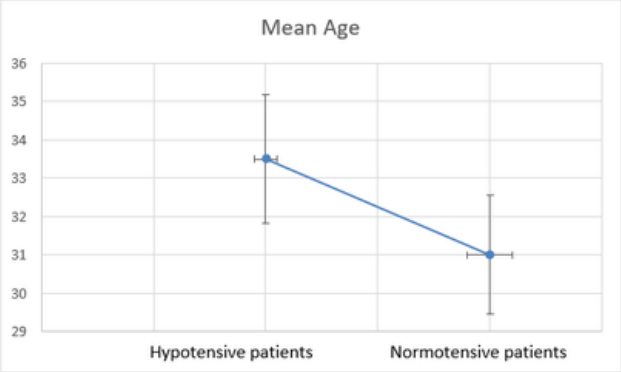

Figure 1. *Distribution of female patients according to age*

Relationship between patient age and the occurrence of hypotension during cesarean section

The average age of patients scheduled for an elective cesarean section was 32 years (SD = 6), with the youngest patient being 20 and the oldest 45 years old. In the hypotensive (H) group, the average age was 33.5 years (SD = 5.5), while in the normotensive (N) group, the average age was 31 years (SD = 6). Using Student's t-test, a statistically significant difference between the groups was found (t = 2.183, p = 0.031). On average, patients who experienced hypotension during surgery were older, as shown in Figure 1.

Association between body weight and the occurrence of hypotension during cesarean section

The average body weight of the participants was 85 kg (SD = 15), with a maximum of 126 kg and a minimum of 57 kg. However, the average weight within the group of hypotensive and normotensive patients differed. Among hypotensive patients, the average weight was 87.2 kg (SD = 15.3), while in normotensive patients, the average weight was lower, at 83.3 kg (SD = 15). The Shapiro-Wilk test, used to assess deviation from normality, showed a statistically significant difference ($p < 0.001$) between the weight distribution in Group N and the normal distribution. No statistically significant difference was observed for Group H ($p = 0.220$).

To assess differences in body weight between the N (normotensive) and H (hypotensive) groups, the Mann-Whitney U test was applied. The results indicated no statistically significant difference ($U = 2207.500$, $p = 0.093$). Accordingly, body weight was not identified as a predictive factor for the occurrence of hypotension.

Association of height with the occurrence of hypotension during cesarean section

Among 123 participants, the average height was 167 cm, with the shortest woman at 150 cm and the tallest woman at 183 cm. In the hypotensive group, the average height was 167.8 cm (SD = 6.2), while in the normotensive group, it was 166.4 cm (SD = 6.7). The Shapiro-Wilk test showed a statistically significant deviation from normal distribution in the hypotensive group ($p = 0.023$), but not in the normotensive group ($p = 0.836$). The Mann-Whitney *U* test revealed no statistically significant difference between the groups ($U = 2052.500$, $p = 0.371$). Therefore, height was not identified as a predictive factor for the occurrence of hypotension.

Association of Body Mass Index (BMI) with the occurrence of hypotension during cesarean section

The average BMI was 30.5 (SD = 5.4), ranging from a minimum of 20.9 to a maximum of 44.81. In the hypotensive group, the average BMI was 30.995 (SD = 5.392), and in the normotensive group, it was 30.130 (SD = 5.354). The Mann-Whitney U test showed no statistically significant difference ($p = 0.277$). Hence, BMI is not a predictive factor for the development of hypotension.

Effect of the amount of local anesthetic on hypotension and its relation to height

The local anesthetic used was 0.5% hyperbaric bupivacaine. As shown in Table 1, the average volume of anesthetic administered to shorter hypotensive patients (with systolic pressure < 90 mmHg) was 2.526 ml, while for taller hypotensive patients it was 2.603 ml.

Using the ANOVA test, which was employed to examine differences in the total amount of administered anesthetic in relation to the factors of height and presence of hypotension, it was determined that there was no statistically significant interaction between these two factors ($p = 0.812$), indicating that there was no interaction effect of height and hypotension on the total volume of anesthetic administered. It was also found that there was no statistically significant difference in the amount of anesthetic

Table 1. *Average volume of anesthetic administered by patient height and hypotension status*

Height group	Presence of hypotension	N	Average volume of anesthetic (ml)	Standard deviation (SD)
Short participants	Hypotensive	19	2.526	0.073
	Normotensive	26	2.500	0.160
Tall participants	Hypotensive	37	2.603	0.155
	Normotensive	41	2.590	0.174

administered with respect to the presence of hypotension alone (p = 0.506). However, when the effect of height was examined, a statistically significant difference was found (p = 0.005). This finding suggested that taller patients received a higher amount of anesthetic, regardless of whether hypotension was recorded during cesarean section under spinal anesthesia.

Correlation between height and volume of anesthetic administered

The analysis tested whether there was a linear, logarithmic, or logistic relationship between height and anesthetic volume. The question was whether the administered amount of anesthetic could be better predicted based on height by accounting for the curvature of the function. For the logarithmic model, the correlation (R) was 0.463, and R^2 = 0.214, meaning that about 22% of the variation in anesthetic volume could be explained by height. Adding the logarithmic model to the linear model yielded a small, non-significant improvement (R^2 change = 0.004, p = 0.393). The logistic model showed similar non-significant results (R^2 change = 0.003, p = 0.420).

Using Spearman's correlation, which was chosen over Pearson's due to a non-normal distribution, a moderate and statistically significant correlation was found (r_s = 0.427, p < 0.001).

Surgery time and association between hypotension and prolonged preoperative fasting

Patients were divided into 3 groups based on the time of surgery: 8 AM–10 AM (47 patients), 10 AM–12 PM (34 patients), and after 12 PM (42 patients). The chi-square test (χ^2 = 2.098, p = 0.350) showed no significant difference in the distribution of patients across these time slots.

Further analysis (χ^2 = 0.481, p = 0.786) showed no association between later surgery (after 12 PM) and a higher frequency of hypotension (Table 2).

Time from anesthetic administration to onset of hypotension

Among the 123 participants, 56 experienced hypotension. The time from anesthetic administration to the onset of hypotension was recorded (Table 3).

In the majority of patients (60.7%), a drop in systolic blood pressure was observed at the 10-minute measurement. The earliest drop was observed 5 minutes following administration of the local anesthetic, while in only one patient, the drop in blood pressure occurred 40 minutes after administration.

Table 2. *Frequency of hypotension by time of surgery*

Time of surgery		Presence of hypotension		Total
		Hypotensive patients	Normotensive patients	
8-10 AM	Number of patients	23	24	47
	% of patients out of all during this time	48.936	51.064	100
	% of patients out of all within the group	41.071	35.821	37.333
10-12 PM	Number of patients	14	20	34
	% of patients out of all during this time	41.176	58.824	100
	% of patients out of all within the group	25	29.851	27.642
After 12 PM	Number of patients	19	23	42
	% of patients out of all during this time	45.238	54.762	100
	% of patients out of all within the group	33.929	34.328	34.146
Total	Number of patients	56	67	123
	% relative to hypotension	45.528	54.472	100

Comparison of blood pressure at the beginning of surgery with the lowest recorded blood pressures in relation to the total amount of administered anesthetic

During a cesarean section under spinal anesthesia, the anesthesiologist recorded both systolic and diastolic blood pressure in the anesthesia protocol. Blood pressure was first measured upon entry into the operating room (baseline blood pressure). Next, it was recorded at the time of local anesthetic administration and subsequently every 2–5 minutes. The average difference between baseline systolic blood pressure and the lowest recorded systolic pressure was 46 mmHg (SD = 14). The average difference between baseline diastolic pressure and the lowest recorded diastolic pressure was 24 mmHg (SD = 11.5).

When these average differences in blood pressure were compared with the total amount of administered anesthetic

Table 3. *Time to onset of hypotension*

Time	Frequency	%
5 minutes	15	26.79
10 minutes	34	60.71
15 minutes	3	5.36
20 minutes	2	3.57
25 minutes	1	1.79
40 minutes	1	1.79

using Pearson's test, no statistically significant association was found, neither for systolic pressure (p = 0.621), nor for diastolic pressure (p = 0.734).

Administration of medication during cesarean section

In patients who experienced hypotension during the cesarean section, the anesthesia protocol copies included the documented amounts of phenylephrine and adrenaline administered during the procedure. Among these patients, the average amount of phenylephrine administered was 288.704 µg (SD = 176.721), while the average amount of adrenaline was 23.824 µg (SD = 21.036).

Using Pearson correlation, no statistically significant association was found between patient height (groups V and M) and the total amount of phenylephrine (p = 0.538) or adrenaline (p = 0.857) administered. Both groups received comparable amounts of medication during the surgery.

Frequency of hypotension during surgery in relation to maternal height

Out of a total of 123 participants, hypotension occurred an average of 1.9 times during the surgery (SD = 1.6) in 56 participants. Of these, 33 women experienced hypotension only once, while only one woman experienced hypotension 10 times. Blood pressure lower than 90 mmHg was recorded 2 times on average (SD = 2.172) in the group of shorter hypotensive women (n = 19), while in the group of taller hypotensive women (n = 37), hypotension occurred 1.7 times on average (SD = 1.234). The Mann-Whitney U test did not show a statistically significant difference (U = 358.000, p = 0.906). There was no correlation between maternal height and the occurrence of hypotension.

Correlation between hypertension during pregnancy and the occurrence of hypotension during spinal anesthesia in cesarean section

Table 4. *Presence of hypertension during pregnancy in relation to blood pressure recorded during surgery*

Diagnosis of hypertension in pregnancy		Arterial tension during surgery		Total
		Hypotensive participants	Normotensive participants	
Yes	Number of participants	4	14	18
	Expected number	8	10	18
	% for row	22.2	77.8	100
	% for column	7.1	20.9	14.6
No	Number of participants	52	53	105
	Expected number	48	57	105
	% for row	49.5	50.5	100
	% for column	92.9	79.1	85
Total	Number of participants	56	67	123
	Expected number	56	67	123
	% for row	45.5	54.5	100
	% for column	100	100	100

As shown in Table 4, out of 123 pregnant women, 18 (15%) were diagnosed with hypertension during pregnancy. Using the Chi-square test, a statistically significant difference was found between the groups (χ^2 = 4.618, p = 0.032). Among women without hypertension during pregnancy, almost half were hypotensive (49%), and the other half were normotensive (50%). Among women with hypertension during pregnancy, there were more normotensive women (78%) than hypotensive women (22%).

DISCUSSION

Hypotension during spinal anesthesia is a frequently discussed complication in cesarean sections. The incidence of hypotension varies across studies, with reports indicating that, in the absence of pharmacological prophylaxis, hypotension occurs in 70-80% of cases (17). In our study, hypotension was recorded in 45.53% of participants, which prompted us to consider other risk factors that may have contributed to its occurrence.

Maternal age as a risk factor for hypotension during cesarean section

Several studies have indicated that maternal age is a reliable predictor of hypotension during cesarean sections under spinal anesthesia (24–26). Our findings aligned

with these reports, showing that women who developed hypotension during the procedure were, on average, older. This is consistent with the study by Brenck et al., which established that the significant age cut-off for a higher incidence of hypotension was ≥ 35 years (24). Future research should further examine the characteristics of patients in the ≥ 35-year group to determine which factors may predispose them to a higher risk of hypotension.

Weight and Body Mass Index (BMI) as risk factors for hypotension during cesarean section

In examining the correlation between body weight, Body Mass Index (BMI), and the occurrence of hypotension, studies have shown that patients with higher BMIs are at greater risk for developing hypotension during cesarean sections under spinal anesthesia. Research specifically designed to investigate this correlation has found that the BMI cut-off value ranges from 25 to 29 kg/m^2 (24, 27). In their research, Ohpasanon and colleagues used BMI to predict the spread of local anesthetic after administration (26). Their results indicated that both the size of the uterus and a BMI ≥ 35 contributed to increased intra-abdominal pressure, which led to compression of the subarachnoid space. This compression caused the local anesthetic to spread over a larger area, resulting in more frequent occurrence of hypotension. However, in our study, no correlation between body weight and BMI with the occurrence of hypotension during the cesarean section was observed. A possible reason for this could be the relatively low average BMI of all participants (30.5), as well as the minimal variation between the hypotensive and normotensive groups.

Maternal height and block level

The quality of anesthesia and the incidence of hypotension are closely linked to the level of the spinal block, which is influenced by the amount of local anesthetic administered into the subarachnoid space. When lower doses of local anesthetics are used, the level of block may also depend on the maternal height (12). Our findings indicate that maternal height significantly influenced the block level achieved. Shorter patients predominantly had a block at the L3-L4 level, while taller patients had blocks at both L3-L4 and L2-L3 levels. Although this was not the focus of our study, other studies have noted the significance of maternal height in relation to the spinal column length and the local spread and potency of spinal anesthesia (11,28).

In a 1990 study, Norris investigated the correlation between local anesthetic dose and the distribution of sensory anesthesia, concluding that no dose adjustment was necessary for heights between 146.9 and 174.0 cm (29). However, more recent studies suggest that dosage should be adjusted based on maternal height (10, 12). Our study did not find a statistically significant interaction between the amount of anesthetic administered and maternal height regarding the incidence of hypotension. When comparing the average differences between baseline blood pressure and the lowest recorded blood pressure values in relation to the total amount of anesthetic administered, no statistically significant differences were found for either systolic or diastolic blood pressure. However, the study showed that taller patients received higher amounts of anesthetic, regardless of whether hypotension occurred during spinal anesthesia for the cesarean section. In the group of shorter hypotensive patients (n = 19), an average of 2 instances of blood pressure readings below 90 mmHg was recorded. In the group of taller hypotensive patients (n = 37), hypotension was observed an average of 1.7 times. Therefore, it was concluded that there was no correlation between maternal height and the occurrence of hypotension.

Using a logarithmic function to predict the required amount of local anesthetic, we found that it was significantly simpler to determine the appropriate dosage when the height of the patients was known. Regarding the effect of the anesthetic on hypotension, we also investigated the most common time interval between the administration of the local anesthetic and the onset of hypotension. Hypotension most commonly occurred 10 minutes after the local anesthetic administration. The shortest recorded time was 5 minutes, while in 1 patient, hypotension occurred 40 minutes after the administration. The reason for the delayed onset of hypotension is not necessarily related to the use of local anesthetics. To prevent such causes of hypotension, appropriate monitoring and close cooperation between the anesthesiologist and surgeon during the cesarean section are essential (30).

As part of the study, we also compared the amounts of medication used during the cesarean section in relation to maternal height. In both the tall and short groups of participants, we did not find a statistically significant difference in the total amount of phenylephrine and adrenaline administered. Both groups received an equal amount of medication for hypotension management. In the

literature, phenylephrine is described as a potent, fast-acting vasopressor with a short duration of action, which is highly effective and easily titrated. The combination of high doses of phenylephrine and crystalloid infusion has been shown to be an effective technique for controlling hypotension (30).

Preoperative fasting duration as a risk factor for the development of hypotension

One of the most common methods for preventing hypotension induced by spinal anesthesia is fluid preloading. This technique involves the prophylactic intravenous administration of crystalloid solutions at a volume of 10–20 mL/kg approximately 15–20 minutes prior to local anesthetic injection (31). However, the efficacy of this approach is increasingly called into question because preloading with crystalloids leads to rapid fluid redistribution into the extravascular space, resulting in only a transient increase in intravascular volume. This acute volume expansion can trigger atrial natriuretic peptide secretion, which results in peripheral vasodilation and accelerates the excretion of the previously administered fluids. It has also been established that hypotension mainly occurs shortly after the application of spinal anesthesia, and even a rapid bolus fluid infusion (a technique known as "co-loading") cannot prevent this. There is a research consensus that even large volumes of intravenous fluids cannot prevent hypotension during spinal anesthesia (31).

In our study, we evaluated the development of hypotension during cesarean sections relative to preoperative fasting duration, which was calculated based on the scheduled operation time. The cesarean section surgeries were equally distributed into 3 time intervals: 8:00 AM–10:00 AM, 10:00 AM–12:00 PM, and after 12:00 PM. We observed that patients operated on during the latest interval (after 12:00 PM) were not more likely to experience intraoperative hypotension. Similarly, Husaini and Russell (32) compared a group receiving 1 L of Ringer's solution 10 minutes before spinal anesthesia to a parallel control group receiving no preoperative fluids. In both groups, prophylactic ephedrine infusion was administered immediately after the injection of the local anesthetic. There was no significant difference in the need for ephedrine later, nor did the incidence of hypotension differ between the groups (32). As an improvement to this study, it would be beneficial to compare the data on the quantity of fluids administered preoperatively with the time of surgery and the occurrence of hypotension.

Correlation of hypertension during pregnancy with the development of hypotension during cesarean section

In our study, we also recorded data on whether participants had been diagnosed with hypertension during pregnancy. When comparing hypertension during pregnancy with the occurrence of hypotension during the cesarean section, the results showed that the number of patients who did not have hypertension during pregnancy was almost equal to the number of those who later became hypotensive (49%) and those who remained normotensive (50%). Among patients who had hypertension during pregnancy, there were more normotensive (78%) than hypotensive (22%) women. In a study conducted by Aya et al., patients with severe preeclampsia had a lower incidence of hypotension during cesarean sections under spinal anesthesia (33). Blood pressure was measured and recorded before the application of spinal anesthesia, and every 2 minutes over a period of half an hour afterwards. Despite receiving a smaller volume of fluid and a higher dose of local anesthetic, patients with severe preeclampsia were less likely to experience hypotension. The risk of hypotension was almost six times lower in patients with severe preeclampsia compared to pregnant women with normal blood pressure (33). Animal studies under normal physiological conditions have demonstrated that uteroplacental blood flow exceeds fetal oxygen demand, providing a safety margin against fluctuations in perfusion. Similarly, a retrospective review by Maayan-Metzger et al. of 919 term pregnancies undergoing elective cesarean delivery under spinal anesthesia found that even maternal hypotension exceeding 30–50% from baseline was not associated with adverse perinatal outcomes, supporting the concept of a protective buffer in placental oxygen delivery (16, 25). Other studies suggest that the duration of hypotension may be more critical than its severity, indicating that maternal hypotension lasting longer than 4 minutes could be associated with neurobehavioral changes (6). The data we used for comparison were solely related to the presence of a hypertension diagnosis during pregnancy and the development of hypotension during the cesarean section. A potential topic for future research could be defining preoperative blood pressure values that influence the reduced occurrence of hypotension, as well as variations in the amount of local anesthetic that can be administered to patients who are hypertensive before the onset of anesthesia, compared with those who are not.

The results of our research show that older patients were, on average, more frequently hypotensive during cesarean section under spinal anesthesia. Patients who had hypertension during pregnancy were, on average, less likely to experience hypotension during cesarean section compared with those in whom hypertension was not diagnosed during pregnancy. The participants in the lower-height group were not statistically significantly more likely to be hypotensive than those in the taller group. In our study, the duration of preoperative fasting was not a risk factor for the development of hypotension during cesarean section under spinal anesthesia. Further studies are needed with a larger number of participants to obtain a more representative sample and to allow greater variation among groups.

Acknowledgements

This study was not supported by any sponsor or funder.

Author Contributions

Conceptualization: S.Dj. and A.U.; Methodology, investigation, and data curation: S.Dj.; Formal analysis: S.Dj., A.U., and N.G.; Writing – original draft: S.Dj.; Writing review & editing: A.U. and N.G. All authors have read and approved the published version of the manuscript.

Statement of Ethics

This study protocol was reviewed and approved by the Ethics Committee of the Clinical Center of Vojvodina, approval number 00-113, issued on 23 June 2023. The study was conducted in accordance with the Declaration of Helsinki. As this was a retrospective study based on existing, anonymized anesthesia records, the requirement for individual informed consent was waived by the Ethics Committee.

Statement of Competing Interest

The authors declare no relevant conflicts of interest.

Statement of Data Availability

All data analyzed during this study are included in this published article.

Statement of Generative AI Technologies Use

No generative AI was used.

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