

ORIGINAL RESEARCH

OBSTETRIC ANESTHESIA

Evaluation of tissue oxygenation in cesarean cases under spinal anesthesia: A prospective observational study

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Abstract

Objective: Hypotension is common in cesarean section due to the sympathetic blockage induced by spinal anesthesia. We aimed to investigate the effect of vasoactive drugs and fluids, and uterotonic drugs on tissue oxygenation.

Methodology: Patients scheduled for elective cesarean section were included in this study. Routine monitoring values, thenar oxygen saturation and hemoglobin (Hb) indices were recorded preoperatively at the operating table (T1), at 3rd minute after spinal block (T2) and after the administration of uterotonic drugs (T3).

Results: Data of 61 patients were analyzed. In 24 cases (39%), Hb values were < 11 g/dl. The incidence of hypotension following spinal anesthesia was 34.4%. The mean amount of ephedrine administered before the baby removal was similar in all patients (214 mg). Baseline StO₂ values of anemic patients were similar to that of non-anemic patients; tissue hemoglobin index values of the former were significantly lower ($p = 0.017$). T3 systolic arterial blood pressures of patients with intraoperative hypotension were significantly lower ($p = 0.001$); tissue oxygen saturation and Hb indices were similar ($p = 0.301$).

Conclusion: Tissue oxygenation may be influenced by the presence of anemia, hypovolemia, and hypotension. Its measurement may be influenced by pregnancy-dependent factors like edema and adipose tissue thickness in the monitoring site. We found that maintaining systolic blood pressure above 100 mmHg in this patient cohort was sufficient to preserve tissue oxygenation despite presence of anemia; and tissue oxygen saturation and hemoglobin indices were reliable.

Key words: Cesarean section; Spinal anesthesia; Tissue oxygen saturation; Tissue hemoglobin index; Anemia

Citation: Özdemir A, Hizal A, Erdivanli B, Kartal S, Şen A. Evaluation of tissue oxygenation in cesarean cases under spinal anesthesia: A prospective observational study. *Anaesth. pain intensive care* 2021;25(3):280–286. DOI: [10.35975/apic.v25i3.1529](https://doi.org/10.35975/apic.v25i3.1529)

Received: September 17, 2020; **Reviewed:** February 6, 19, 2021; **Revised:** February 16, 2021; **Accepted:** May 12, 2021

1. Introduction

For maternal safety, the majority of cesarean sections are performed with spinal anesthesia.¹ Hypotension may be observed as a result of decrease in systemic vascular resistance due to sympathetic blockage induced by spinal anesthesia. Due to vasodilation, preload of the heart decreases, and consequently, cardiac output decreases. To compensate for this, the heart rate increases.² Despite hydration and vasopressor use, hypotension is still common after spinal block.³ In addition, there are publications reporting that oxytocin, which reduces blood loss by strengthening the contraction of uterine muscles, can cause systemic and coronary vasoconstriction.⁴ and adverse effects especially in patients with cardiopulmonary risk factors.⁵

We aimed to investigate the effect of uterotonic drugs administered to reduce blood loss due to uterine bleeding, and fluid and ephedrine applied for treating hypotension on tissue oxygenation. For this purpose, we planned to use the near-infrared spectroscopy (NIRS) technique. NIRS provides information about tissue oxygenation with measurements obtained non-invasively from certain areas of the body. This technology can provide information about tissue oxygenation and tissue hemoglobin (Hb) level through interpretation, by special software, of the reflections of rays sent non-invasively (over the skin) with the help of a special probe in the wavelength range of 700-850 nm.⁶

We aimed to evaluate hypotension, hypovolemia, and the effects of IV administration of fluid, ephedrine and routinely used uterotonic drugs on microcirculation in elective cesarean section cases performed with spinal anesthesia, considering tissue oxygen saturation (StO₂) and tissue hemoglobin index (THI). For this purpose, we planned an observational pilot study.

2. Methodology

Following approval of the Local Ethics Committee (date: 26.09.2019, decision number: 2019/153), parturients with American Society of Anesthesiologists (ASA) risk score II, who were scheduled for elective cesarean section, were included in the study. Patients with a systemic disease, receiving additional sedation or general anesthesia

during the case, receiving ephedrine before spinal anesthesia, Hb < 8g/dl and Hb > 14g/dl, obese (body mass index >30 kg/m²), and not having signed the informed consent form were excluded from the study.

Arterial blood pressure and pulse measured preoperatively while the patient was in sitting position on the operating table (T1), in addition to oxygen saturation (SpO₂) measured using finger probe from the arm where blood pressure was not measured, as well as tissue oxygen saturation (StO₂) measured from the hand thenar in order to evaluate tissue oxygenation, and tissue hemoglobin index (THI, InSpectra StO₂ Tissue Oxygenation, Hutchinson Technology Inc., Hutchinson, MN, USA) were recorded. Preoperative Hb values were recorded alongside with the amount of intravenous fluid the patient received up to that point. Spinal anesthesia was performed in sitting position, using a 25-gauge needle from the L₃₋₄ vertebral space, with hyperbaric 0.5% bupivacaine. The local anesthetic dose was determined by the anesthetist targeting the T4 level according to the height and weight of the patient. Following spinal anesthesia, the patient was tilted 15° to the left side in the supine position.

Intravenous crystalloid fluid infusion was initiated to all patients. In the cases, hypotension was found to be treated with 5 mg of IV ephedrine doses that were repeated if necessary. Administered ephedrine doses were recorded.

According to the protocols of Department of Obstetrics and Gynecology; oxytocin 20 IU was administered in 500 ml saline for 20 min, alongside with methylergonovine 0.2 mg i.m. after clamping the umbilical cord, for uterotonic purposes.

In addition to baseline measurements, in two stages, one in the supine position with 15° tilt to the left side at the third minute after spinal anesthesia (T2) and the other at the end of oxytocin infusion (T3), arterial blood pressure, pulse, SpO₂, StO₂, THI values, and the amount of ephedrine and IV fluid administered were recorded.

2.1. Statistical Analysis

This observational study aimed for a total of 60 patients to obtain a homogenous distribution of clinical parameters. The data were analyzed by the SPSS 12 packaged software. Demographic data were tabulated with descriptive statistics. Homogeneous

Table 1: Distribution of tissue oxygenation parameters when the patients are grouped according to the preoperative presence of anemia

	Tissue oxygenation parameters	Hb < 11 g/dl (n=23)	Hb ≥ 11 g/dl (n=38)	p value
T1	StO ₂	75.5 ± 6.0	77.5 ± 5.2	0.224
	THI	10.3 ± 1.6	12.2 ± 2.3	0.002*
T2	StO ₂	73.6 ± 6.3	75.4 ± 5.4	0.359
	THI	13.1 ± 15.7	13.1 ± 10.5	0.007*
T3	StO ₂	75.0 ± 8.0	72.5 ± 12.0	0.290
	THI	14.1 ± 21.6	13.3 ± 15.2	0.019*
	IV fluid (ml)	1411 ± 469	1488 ± 496	0.468
	IV ephedrine (mg)	12.4 ± 9.6	10.7 ± 10.8	0.522

Data given as mean ± standard deviation. T-test was used in the analysis.

Table 2: Distribution of tissue oxygenation parameters and arterial blood pressure values when the patients are grouped according to intraoperative ephedrine administration

	Tissue oxygenation parameters	Ephedrine administered (n=32)	No ephedrine (n=29)	p value
T1	Hb (g/dl)	11.4 ± 1.1	11.1 ± 1.3	0.334
	StO ₂	77.5 ± 5.0	75.9 ± 6.2	0.491
	THI	11.3 ± 2.2	11.7 ± 2.4	0.398
	IV fluid (ml)	475.0 ± 378.7	289.7 ± 325.5	0.040*
T2	StO ₂	75.1 ± 5.2	74.3 ± 6.3	0.920
	THI	10.5 ± 1.8	11.3 ± 2.1	0.106
	IV fluid (ml)	895.3 ± 471.8	591.4 ± 363.0	0.013
T3	StO ₂	74.6 ± 6.7	74.6 ± 6.3	0.986
	THI	10.3 ± 1.7	10.5 ± 1.7	0.668
	IV fluid (ml)	1631.2 ± 497.4	1269.0 ± 394.9	0.004*

Data were given as mean ± standard deviation. T-test was used in the analysis

distribution of data was evaluated with the Kolmogorov-Smirnov test. Categorical data were presented as numbers (percentage), whereas continuous variables as arithmetic mean and standard deviation if they conformed to normal distribution, and as median (interquartile range) if they did not.

In this observational study, hypotension after spinal anesthesia was defined as more than 20% decline in baseline systolic blood pressure or systolic blood pressure less than 100 mmHg.7). Anemia was defined

as having a Hb value below 11 g/dl according to the World Health Organization (WHO) (8).

On posthoc analysis, the patients were divided into groups regarding the incidence of anemia, intraoperative arterial hypotension, and the need for ephedrine. Chi-square test was used to compare categorical data, while t-test or Mann-Whitney U test were used to compare numerical data. The statistical significance level was accepted as $p < 0.05$.

Table 3: Distribution of tissue oxygenation parameters and arterial blood pressure values when the patients are grouped according to development of intraoperative hypotension

	Tissue oxygenation parameters	Hypotensive (n=21)	Normotensive (n=40)	p value
T1	IV fluid (ml)	377.1 ± 412.8	393.2 ± 333.8	0.586
	StO ₂	7.6 ± 4.5	77.5 ± 6.1	0.213
	THI	11.6 ± 2.0	11.4 ± 2.4	0.850
	SAP	139.4 ± 15.4	134.6 ± 14.5	0.174
T2	IV fluid (ml)	747.9 ± 471.5	752.7 ± 437.3	0.832
	StO ₂	75.0 ± 5.6	74.6 ± 5.9	0.764
	THI	10.8 ± 2.1	10.9 ± 1.9	0.870
	SAP	108.8 ± 16.4	128.1 ± 14.0	< 0.001*
T3	IV fluid (ml)	1564.6 ± 492.7	1390.5 ± 471.7	0.201
	StO ₂	75.3 ± 7.1	74.3 ± 6.2	0.613
	THI	10.2 ± 1.7	10.4 ± 1.7	0.695
	SAP	119.1 ± 16.7	119.1 ± 22.5	0.460
	IV ephedrine (mg)	12.4 ± 10.1	10.7 ± 10.6	0.439

Data given as mean ± standard deviation. T-test was used in the analysis.

3. Results

The mean age of the patients included in the study was 31.3 ± 6.8 y. In 24 (39%) of the cases, Hb value was 11 g/dl and below.

While baseline StO₂ value of the cases varied between 60-88%, a Hb value of 8.6 g/dl was found in one case with a StO₂ value of 60.

The mean amount of fluid that patients received before spinal anesthesia was 290 ± 62 ml. A total of 11 patients (18%) had not been given IV fluid preoperatively. During the operation, ephedrine was administered to 29 (48%) cases, and the total amount of ephedrine was 21 ± 4 mg. The incidence of hypotension following spinal anesthesia was 34%.

3.1. Presence of anemia

StO₂ values of anemic patients at T1 were similar to that of non-anemic patients, whereas THI values of the former were significantly lower compared to the latter (p < 0.001). The total amount of fluids and the dose of ephedrine administered during the operation were similar (p > 0.05, Table 1).

3.2. Use of ephedrine

The total amount of fluid administered in the intraoperative period was significantly lower in patients treated with ephedrine compared to those who were not (p = 0.004, Table 2).

Systolic arterial blood pressures of patients grouped according to administration of ephedrine are shown in Figure 1.

3.3. Incidence of intraoperative hypotension

The data of patients grouped according to the incidence of intraoperative hypotension is given in Table 3. In summary, T2 systolic arterial blood pressures of patients who developed intraoperative hypotension were significantly lower (p = 0.001), while their tissue oxygenation parameters were similar. On screening, it was observed that their hemodynamics and tissue oxygenation parameters progressed similarly. The amounts of fluid and total ephedrine administered to both patient groups were similar.

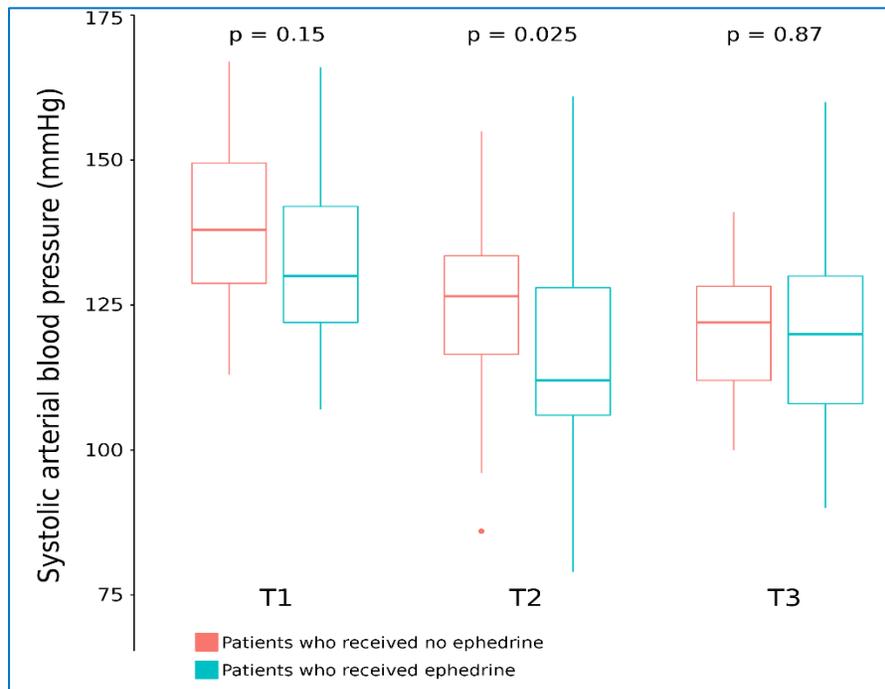


Figure 1: Systolic blood pressures of patients grouped according to administration of ephedrine

4. Discussion

Prevention and treatment of hemodynamic instability during cesarean section is vital for the fetus and the mother. Prevention and treatment of systemic hypotension due to spinal anesthesia is essential for tissue oxygenation. Tissue oxygenation depends on many factors such as cardiac output, Hb value, volume status and hypoxia. NIRS is a technology offering advantages in the noninvasive assessment of tissue oxygenation and tissue hemoglobin concentration. There are various studies in the literature in which this technology is used in intensive care units and operating rooms.⁶

Although red blood cell production by erythropoiesis increases during pregnancy, dilutional anemia develops due to the increase in plasma volume. According to the definition of World Health Organization, Hb value below 11 g/dl is considered as anemia, and its prevalence is 38% in pregnant women.⁸). Similarly, the rate of anemia was determined to be 37.7% in our study.

StO₂ values were similar in patients with and without anemia, whereas significant difference was seen

between baseline THI values. Although Hb levels decrease in anemic patients, oxygen extraction ratio increases in tissue. Studies investigating critical care patients report that this causes a decline in venous oxygen level and, hence, lower StO₂ values.⁹ Tissue oxygen levels are affected by the balance between local oxygen delivery and consumption.¹⁰ Since the patients included in our study have a low ASA physical status score, we are in opinion that their capacity for oxygen extraction is sufficient to compensate for an uncomplicated cesarean section operation.

Severity of anemia and levels of hypovolemia and hypotension

are the parameters that affect oxygenation. The fact that these parameters were observed as mild to moderate in the present study may explain similar StO₂ values in anemic and non-anemic patients. In addition, the site where monitoring is carried out and factors such as edema and adipose tissue thickness therein (in terms of change during pregnancy) also affect measurements.¹¹

Ephedrine is a sympathomimetic agent that is particularly used in the treatment of spinal anesthesia-induced hypotension. Cardiac output increases due to vasoconstriction and cardiac stimulant effect.¹²

In our study, although the total amount of fluid administered was higher in the non-ephedrine group, there was no difference between the two groups in terms of StO₂ and THI values. As microvascular circulation is preserved when vasoactive drugs are used in the treatment of hypotension caused by the change in volume, there may be no changes in StO₂ values.¹¹

The incidence of maternal hypotension after spinal anesthesia is approximately 60-70%. The incidence of maternal hypotension varies depending on the amount of fluid administered in the preoperative period and has been shown to decrease by the amount of

crystalloid given.^{13,14} In the present study, the amount of fluid (total fluid volume) administered in the non-ephedrine patient group was statistically higher than the ephedrine group. The number of patients who received ephedrine alongside fluid replacement after spinal anesthesia was 29 (47%), while the number of patients with hypotension was 21 (34%), suggesting that the patients were administered ephedrine at an early phase by anesthetists.

In our study, when normotensive and hypotensive patients were compared, there was no statistically significant difference between the StO₂ and THI values measured at baseline, at 3rd min and at the end and the amounts of fluid administered. It has been shown that StO₂ values measured from the thenar area cannot provide sufficient data in mild and moderate hypovolemic shock.^{15,16} The fact that the systolic blood pressure was not reduced to below 100 mmHg in both patient groups and that the pregnant women included in the study were ASA I may explain why tissue oxygenation was maintained in these patients. Alternatively, it may also explain that these values have remained stable due to the balance kept between delivery and consumption.

5. Limitation

The present study has many limitations related to its observational and pilot study design. In accordance with routine practice, lactate, central venous oxygen saturation and similar laboratory parameters for tissue oxygenation were not monitored. In order to avoid hyperoxemia, intraoperative oxygen support was limited to 2 l/min. However, no monitoring has been performed other than peripheral oxygen saturation (such as arterial blood gas, oxygen reserve index, etc.). Cases with ASA score above II as well as emergencies were excluded. No complications that could affect tissue oxygenation were encountered. Therefore, the results we have obtained cannot be extended to patients other than cases of elective cesarean section.

6. Future direction

Our study determined that maintaining systolic arterial blood pressure above 100 mmHg in cases of elective cesarean section with spinal anesthesia was sufficient to preserve tissue oxygenation. It also showed that the use of either fluids or vasoactive drugs to maintain

blood pressure at the abovementioned level are able to preserve tissue oxygenation; and use of uterotonic drugs is not related to tissue hypoxia. We think that the InSpectra device can reliably display tissue oxygenation parameters in this patient group. We recommend randomized, controlled studies to be conducted with higher-risk patient groups in which hypotension treatment is protocolized as intravenous fluid or ephedrine.

7. Conflict of interest

None declared by the authors

8. Authors' contribution

AÖ: Concept, manuscript writing, literature review, data collection

AH: Manuscript writing, data collection, data processing

BE: Data processing, data analysis, manuscript editing

SK: Data analysis, manuscript editing, literature review

AŞ: Literature review, critical review

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