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Comparison of the effects of hydroxyethyl starch and succinylated gelatin infusion on the perfusion index in elective caesarean sections under spinal anaesthesia

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ABSTRACT

Aim: This study is to compare the alterations of three different replacement fluids on Perfusion Index, Pleth Variability Index (PI, PVI) and hemodynamic data in cases planned to experience caesarean surgery under spinal anaesthesia.

Material and Method: 94 ASAII class patients aged 18–40 that were planned to experience caesarean surgery were included in the study. The patients were divided into three groups according to the fluid replacement to be applied. Patients in Group H received 10 ml/kg of hydroxyethyl starch (HES) up to a maximum of 500 ml over 20 minutes. Patients in Group G got 10 ml/kg of modified liquid gelatin(GEL) up to a maximum of 500 ml over 20 minutes. Patients in Group I got 20 ml/kg of isotonic sodium chloride (0.9% NaCl) over 20 minutes. Routine monitoring and perfusion index, pleth variability index were recorded baseline and at the first, third and tenth min after spinal anaesthesia for all participants

Results: A significant increase in the PI value over time was observed in Groups G and I (p=0.001*). According to the PVI results, the amount of decrease in Group G was statistically less than in the other two groups (p=0.015*).

Conclusion: In conclusion, 0.9% NaCl and gelatine were more effective on PI in caesarean section under spinal anesthesia. Isotonic has a positive effect on both PI and PVI. We detected that PI increased compared to baseline values, and believe that this increase may a positive effect on tissue circulation in the patient.

Keywords: Hydroxyethyl starch, succinylated gelatin, perfusion index

INTRODUCTION

Spinal anaesthesia is the opted anaesthesia method in caesarean surgeries because it eliminates the potential risks associated with airway management in pregnant women (1). Hypotension result of spinal anaesthesia during caesarean section occurs due to reduced vascular resistance from sympathetic blockade. Reduced cardiac output causes blood pooling formation in plugged regions of the body (2). The incidence and severity of hemodynamic instability can be reduced by tilting the patient in a left lateral position and applying various techniques, including vasopressor drug administration, manual uterine displacement maneuvers, and preloading with crystalloid or colloid (3,4). Crystalloid and colloid solution loadings from these applications can effectively normalise blood volume and arterial blood pressure (5). The PI is calculated as the ratio of pulsatile blood flow to nonpulsatile flow in the peripheral extremity and is utilized as a rapid indicator of microcirculatory changes. It provides continuous information about tissue perfusion in a non-invasive manner. Because of its ease of use, it has become the preferred hemodynamic monitoring method for patient follow-up (6). PI can be described as the rate of nonpulsatile current (AC) to pulsatile flux (DC) in the capillary area. PI (%)=(AC: DC) x 100 using the maximum and minimum PI, PVI can be calculated as follows. PVI (%)= [(PI max - PI min) / PI max] x 100 provides dynamic automatic assessments in the course of the respiratory period. It is used via a non-invasive, finger/ear connected oximetry probe (7). In addition, PVI has been demonstrated as a firm indicator of hypotension in anaesthesia induction (8) and can be used as a guide for maintaining fluid response in mechanically ventilated cases (9). However, in spontaneously breathing cases, the determination of fluid response transforms difficult as tidal volume and respiratory frequency differ (10)Primary the present research is aimed to compare the alterations of three different replacement fluids on PI, PVI and hemodynamic

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data in cases planned to experience caesarean surgery under spinal anaesthesia. Secondarily, the replacement fluids we gave were to provide hemodynamic stability and to determine the amount of increase in blood PI.

MATERIAL AND METHOD

The study was carried out with the permission of Malatya Turgut Özal University Clinical Researches Ethics Committee (Decision No: 2021/65). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Clinical study was planned prospectively.

A total of 94 ASA II class patients aged 18–40 that were planned to experience caesarean surgery were included in the study. The number of patients was planned based on the number of patients in similar studies (11-13). The emergency cases, aged smaller than 18 or over 40 years, gestational aged smaller than 36 weeks or over 41 weeks, the value of body mass index (BMI) ≥ 40, refusal to participate, presence of placenta previa, preeclampsia, cardiovascular disease, Raynaud's disease, fetal complications, or contraindications to spinal anesthesia were created as exclusion criteria.

Patients who developed insufficient block and perioperative hypotension were excluded from the study.. All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants who participated in this study. The patients were divided into three groups according to the fluid replacement to be applied. All participants fasted for at least 8 hour In the operation room venous access was maintained and standard monitoring electrocardiography (ECG), partial oxygen saturation (SpO_2), non-invasive blood pressure (NIBP) was applied. Basal systolic arterial pressure (SAP), mean arterial pressure (MAP), as well as diastolic arterial pressure (DAP), heart rate (HR), and SpO_2 were recorded. A Masimo Radical 7 pulse oximeter probe (Masimo Corp., Irvine, CA, USA) was connected to the forefinger of the right hand and protected from light. Then, PI, PVI, peripheral blood oxygen content (SPOC) (mL/dL) and peripheral blood haemoglobin (SpHb) (g/L) were recorded. Patients in Group H received 10 ml/kg of hydroxyethyl starch (Corn-based 130/0.4 hydroxyethyl starch, sodium chloride (HES)) up to a maximum of 500 ml over 20 minutes. Patients in Group G got 10 ml/kg of modified liquid gelatin (500 ml solution 20.0 g succinylated gelatin, 3.505 g sodium chloride (GEL)), up to a maximum of 500 ml over 20 minutes. Patients in Group I got 20 ml/kg of isotonic sodium chloride (0.9% NaCl) over 20 minutes.

Fluids were planned as infusions over 20 min and ended at the 10th minute following spinal anaesthesia. The patients were set in a sitting position, and 12–15 mg of hyperbaric bupivacaine was managed by reaching the subarachnoid area with a 25 G Quincke spinal needle from the L4–L5 space. Following the application, the patients were placed on their backs. The sensory block levels were evaluated. The patients SAB, MAP, DAP, SpO_2, HR, PI, PVI, SPOC and SpHb were recorded at the first, third and tenth min after spinal anaesthesia. A reduction of more than 30% from the basal rate or a reduction below 90 mm Hg was considered hypotension.Data analysis was carried out using the IBM SPSS version 26.0 statistical programme (Chicago, IL, USA). Skewness and kurtosis values were utilized to evaluate the normality distribution. Descriptive data were presented as mean and standard deviation values for the quantitative variables. The **demographic data** of the groups were compared with a one-way analysis of variance (ANOVA). A mixed-design ANOVA was utilized to test for significant differences among the groups with repeated measurements. Mauchly's test was used to test the sphericity assumption, and MANOVA was also used. The Duncan test was chosen as a between-group post hoc test, and the Bonferroni correction was used for confidence interval adjustment. A p value of <0.05 was accepted as significant.

RESULTS

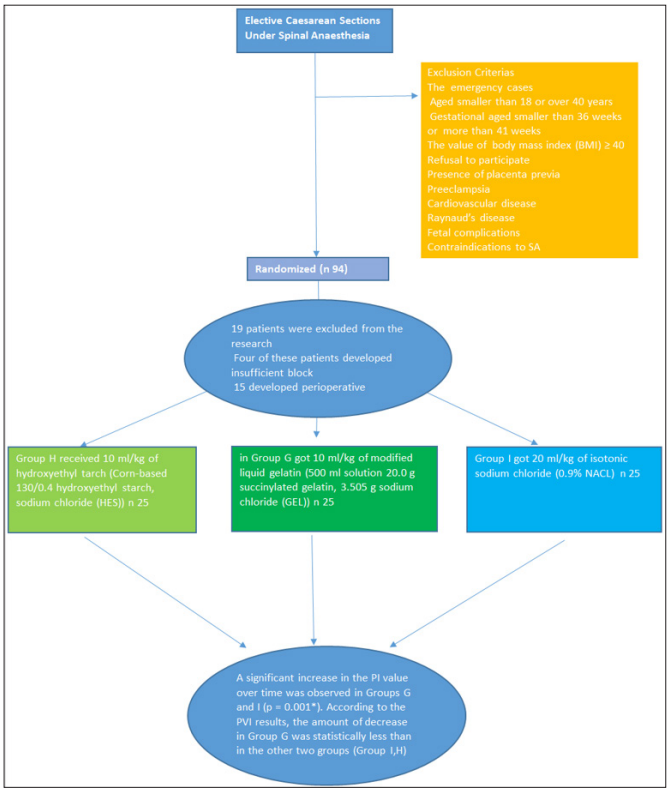
Seventy-five ASA II class cases were included. In total, 19 patients were excluded from the research. Four patients developed insufficient block, and 15 developed perioperative hypotension.

The age was determined as mean±standard deviation (30.32±4.779). Patient BMI was determined as mean ± standard deviation (29.4278±6.36174). Demographics were similar in three groups. A significant increase in the PI value over time was observed in Groups G and I (p=0.001*). A statistically significance was observed

Demographics Datas					
	Group G Mean±Std.deviation (n=25)	Group I Mean±Std.deviation (n=25)	Group H Mean±Std.deviation (n=25)	TOTAL Mean±Std.deviation (n=75)	P value
Age	29.12±4.333	31.68±5.266	30.16±4.525	30.32±4.779	0.164
Height (cm)	163.80±6.357	160.60±10.966	157.64±5.634	162.01±8.013	0.359
Weight (kg)	76.12±8.136	79.60±12.007	73.84±10.032	76.52±10.322	0.139
BMI	28.4494±3.41831	31.6228±9.79918	28.2111±3.08570	29.4278±6.36174	0.105
BMI. Body Mass Index					

between the groups for the third and fourth measurements (p=0.029*). Group H values were more stable and lower than those of the other two groups. The PI values showed more variation and were increased in Groups G and I compared to Group H (**Table 1**) The between-group evaluation of PI showed significant differences between Groups I and H for the third measurement (p=0.028*) and between Groups G and H for the fourth measurement (p=0.007*) (**Figure 1**). When PI values were evaluated according to time, a significance was obtained between the second and third measurements in Group G (p=0.001) and between the second and third evaluations in Group I (p=0.005*). In Group H, no significance was obtained in terms of time.When the change in PVI was evaluated according to time, a significant decrease was observed (p=0.001*). According to the PVI results, the amount of decrease in Group G was statistically less than in the other two groups (p=0.015*) (**Figure 2**). When PVI was evaluated among the groups, there was a statistical significance was observed between Group G and Group I in the second measurement (p=0.026*). When evaluated in terms of time, there was no difference in Group G, whereas in Group I, there was a difference in the second and third measurements (p=0.014*) and the third and fourth measurements (p=0.012*). A significance was found among the first and second measurements in Group H (p=0.027*) (**Table 2**).

Examination of SAP, DAP, MAP, HR, SPOC and HGB



Flow Chart

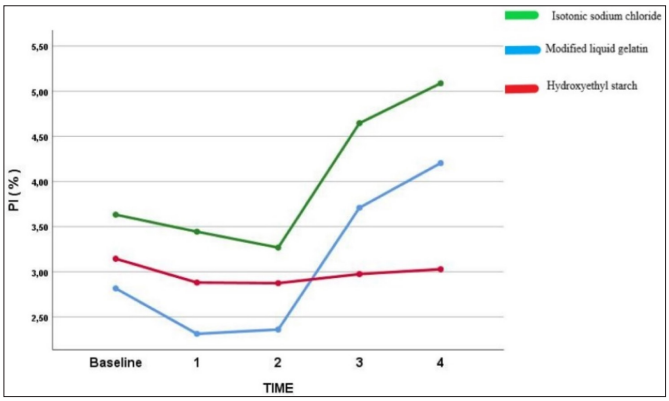


Figure 1. Perfusion Index Between Group

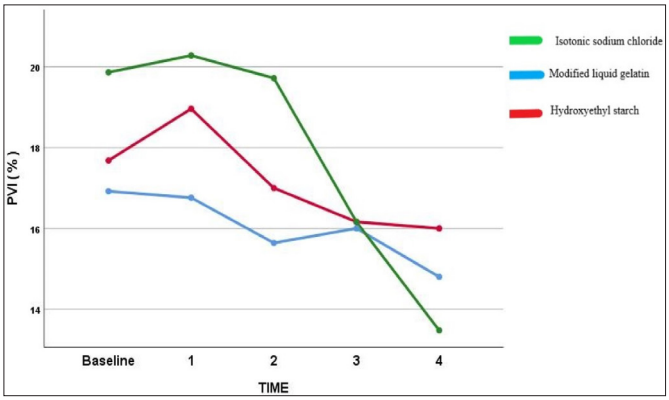


Figure 2. Pleth Variability Index Between Groups

Table 1. Perfusion index value

Perfusion Index	Group G	Group I	Group H	Total	Main effect		Interraction effect
	Mean±Std.deviation (n=25)	Mean±Std.deviation (n=25)	Mean±Std.deviation (n=25)	Mean±Std.deviation (n=75)	Time	Group	
Baseline	2.816±1.25422	3.632±2.04037	3.144±2.02322	3.197±1.81711			
1st measurement	2.3124±1.36763	3.4440±1.75145	2.8800±1.86257	2.8788±1.71550			
2nd measurement	2.3596±1.13138	3.2680±2.07580	2.8736±2.04917	2.8337±1.82063	p=0.001*	p =0.029*	p=0.025*
3rd measurement	3.7088±2.20316	4.6460±2.24174	2.9740±2.02398	3.7763±2.23768			
4th measurement	4.204±2.29265	5.088±2.57331	3.028±1.72736	4.107±2.35408			

Source of Difference for Interaction (Group x Time) for Group		Source of Difference for Interaction (Group x Time) for Time	
Pairwise Comparison (Group)		**Pairwise Comparison (Time)**	
Baseline	-	Group G	(2-3) p=0.001*
1st measurement	(P=0,064)	Group I	(2-3) p=0.005*
2nd measurement	(P=0,211)	Group H	No significant difference
3rd measurement	P=0.028* (Group I - Group H) (Group G - Group H)	* There is a significant difference	
4th measurement	P=0.007* (Group G -C) (Group G - Group H)		

Table 2: Pleth variability index value

Pleth Variability Index	Group G	Group I	Group H	TOTAL	Main Effect		Interraction Effect
	Mean±Std. deviation (n=25)	Mean±Std.deviation (n=25)	Mean±Std. deviation (n=25)	Mean±Std. deviation (n=75)	Time	Group	
Baseline	16.92±6.670	19.864±6.667	17.680±5.422	18.155±6.321			
1st measurement	16.76±5.861	20.28±5.990	18.96±5.184	18.67±5.799			
2nd measurement	15.64±5.574	19.72±6.655	17.00±3.227	17.45±5.544	p =0.001*	p=0.015*	p=0.037*
3rd measurement	16.00±3.841	16.16±6.169	16.16±5.031	16.11±5.034			
4th measurement	14.80±5.354	13.476±4.551	16.000±4.282	14.759±4.800			

Source of Difference for Interaction (Group×Time) for Group		Source of Difference for Interaction (Group x Time) for Time	
Pairwise Comparison (Group)		**Pairwise Comparison (Time)**	
Baseline	-	Group G	No significant difference (p>0,05)
1st measurement	(p=0.094)	Group I	(2-3)=0.014 * . (3-4)=0.012*
2nd measurement	(Group G - Group I) p= 0.026*	Group H	(1-2)=0.027*
3rd measurement	(p=0.992)	* There is a significant difference	
4th measurement	(p=0.178)		

values revealed no significant difference among the groups. Results showed that changes according to time and hemoglobin values displayed no significance among the groups for all three replacement fluids (**Table 3**).

Table 3. Hemodynamic Value

M (measurement) B (Baseline)	Group G	Group I	Group H	TOTAL	Main Effect		Interraction Effect
	Mean±Std. deviation (n=25)	Mean±Std. deviation (n=25)	Mean±Std. deviation (n=25)	Mean±Std. deviation (n=75)	Time P value	Group	
SAP						p =0.664	p=0.387
B	120.84±12.392	123.40±9.857	121.80±17.923	122.01±13.661	-		
1st M	117.04±13.466	118.48±11.594	118.92±15.354	118.15±13.45	0.386		
2nd M	104.24±13.386	112.60±15.147	111.76±14.914	109.53±14.798	0.014		
3rd M	113.64±16.124	115.52±13.522	116.04±13.545	115.07±14.290	0.249		
4th M	113.24±12.417	114.84±14.141	107.88±14.855	111.99±13.695	0.995		
DAP						p=0.324	p =0.651
B	73.76±12.869	76.12±9.833	76.88±12.755	75.59±11.816	-		
1st M	72.64±12.767	72.48±11.917	72.72±11.141	72.61±11.798	0.637		
2nd M	61.28±14.965	68.32±12.750	65.88±14.406	65.16±14.188	0.163		
3rd M	64.88±11.245	68.76±9.658	70.60±10.809	68.08±10.720	0.628		
4th M	62.76±14.624	62.96±11.929	65.64±12.540	63.79±12.971	0.593		
MAP						p =0.523	p =0.472
B	87.36±13.181	90.80±8.134	90.68±13.050	89.61±11.646	-		
1st M	88.36±12.714	87.40±10.618	88.04±12.061	87.93±11.676	0.368		
2nd M	74.32±13.582	81.28±11.585	79.72±13.437	78.44±13.074	0.089		
3rd M	78.48±11.369	80.80±12.069	82.88±10.256	80.72±11.250	0.493		
4th M	79.40±13.054	77.16±13.015	107.88±13.478	88.15±13.053	0.452		
HR						p=0.186	p=0.870
B	92.72±12.908	96.60±12.332	98.72±15.085	96.01±13.543	-		
1st M	99.96±20.535	102.96±17.932	103.36±19.213	102.09±19.056	0.875		
2nd M	96.36±21.614	101.72±12.749	103.08±24.449	100.39±20.165	0.811		
3rd M	94.20±17.630	96.56±16.917	105.36±14.660	98.71±16.932	0.406		
4th M	132.72±11.096	97.08±13.823	101.12±17.624	110.31±14.376	0.356		
SPOC						p =0.764	p =0.501
B	15.60±1.683	15.60±1.803	15.36±1.729	15.52±1.719	-		
1st M	15.60±1.683	14.96±1.399	15.80±2.041	15.45±1.742	0.089		
2nd M	15.52±1.418	15.32±1.345	15.88±2.128	15.57±1.662	0.374		
3rd M	14.76±1.665	14.80±1.528	14.96±2.208	14.84±1.801	0.666		
4th M	14.796±1.528	14.680±2.0207	14.800±1.8868	14.759±2.0842	0.898		
SpHb						p=0.523	p=0.328
B	11.808±1.1751	11.640±.9354	12.008±1.4212	11.819±1.1873	-		
1st M	16.400±1.2747	11.516±1.0526	12.044±1.4933	13.320±1.2879	0.801		
2nd M	11.884±1.0562	11.424±1.1727	12.004±1.4490	11.771±1.2458	0.335		
3rd M	14.992±1.2339	14.756±1.2164	15.416±1.7781	15.055±1.4222	0.529		
4th M	11.496±1.2512	11.264±1.3610	11.220±1.4972	11.327±1.3603	0.100		

SAP Systolic Arterial Pressure, DAP Diastolic Arterial Pressure, MAP Mean Arterial Pressure, HR Heart Rate, SPOC Peripheral BloodOxygen Content, SpHb Peripheral Blood Haemoglobin.

DISCUSSION

Spinal anaesthesia is a proven method for caesarean section and has prevented common complications of general anaesthesia, including difficult intubation, rised risk of gastric acid aspiration and fetal hypoxia during pregnancy (14,15).A regular pregnancy is characterised by a reduction in systemic vascular resistance and an increase in total blood volume as well as cardiac output. In particular, after the thirtieth week of pregnancy, extra blood volume is retained in the extremities as an outcome of reduction in vascular tone caused by pregnancy (16). Despite its advantages (e.g., direct inception of activation and sufficient quality of both sensory and motor blockage), hemodynamic impairment following spinal anaesthesia for caesarean section remains a prevalent and severe complication (3).Hypotension induced by spinal anaesthesia due to reduced systemic vascular resistance and reduced cardiac output, mainly as a result of the preganglionic sympathetic fibres block (17).Crystalloid preloading before spinal anaesthesia procedure is suggested to decrease the ratio of hypotension, but its usefulness is controversial (18). Despite the controversy, prehydration with crystalloid or colloid is widely used prior to spinal anaesthesia. Marx and Wollman noted the significance of fluid infusion in counteracting the relative hypovolemia caused by spinal anaesthesia. Several fluids, such as crystalloids and colloids, have been utilized for preloading prior to spinal anaesthesia for caesarean procedure (19). Park et al. (20) examined the alterations of modified volumes of crystalloid application and their alterations on maternal hemodynamic and colloid osmotic pressure. They pointed out that the groups administered 20 and 30 ml/kg crystalloid indicated a greater decrease in maternal colloid osmotic pressure than the one administered 10 ml/kg crystalloid .

Mathru et al. (21) pointed out that the infusion of 5% albumin in 5% dextrose (15 ml/kg) in lactated ringers with left uterine displacement was an efficient way of preventing hypotension in the course of caesarean section under spinal anaesthesia. Crystalloid solutions classically have short half-lives and weak plasma volume-expanding effects. For these reasons, crystalloid preload may be insufficient to eliminate hypotension due to spinal anaesthesia. Crystalloid preloading at high volumes may additionally reduce oxygen-carrying ability and rise the risk of peripheral and pulmonary edema in pregnant women (22). Colloids that can remain in the circulation for a long time seem to be more suitable options for preventing hypovolemia due to spinal anaesthesia (23). However, any solution including artificial macromolecules such as dextran, HES or gelatin may carry an increased viscosity compared with plasma, based on the size and organization of these molecules and their exact concentration in the blood may induce increased plasma viscosity, especially following extended or recurrent utilization of dextran 40,000-60,000-70,000 and HES (22). Although these alterations are quite small and well below the values that occur physiologically in the late period, some authors have hypothesised that organ blood flow and tissue oxygenation may be compromised (24).In our study, we observed that PI values increased in all groups. Administration of 500 cc of colloid fluids did not impair the PI, and improvement was observed in the peripheral circulation as a result of volume replacementIn a study conducted in healthy volunteers, 1 L infusion of 4% succinylated gelatin in 0.7% saline and 6% HES in 0.9% saline, (over 1 h) had a significant effect on the blood volume expansion capacity, and no difference was observed (25). A novel human research showed that in the early stage following cardiac surgery, the influence of one dose of HES solution on cardiac index was superior to that of the gelatin-administered group (26). Rittoo and colleagues demonstrated that microvascular perfusion and oxygenation were sufficiently maintained with HES infusion than with Gelofusin (27). In another study, circulatory disorders were more common in patients who took gelatin than in those who took albumin (28). Peripheral PI alterations a respond to local blood volume pulsations and changes in intravascular pulse pressure; both of them are influenced by the elasticity of the vascular wall or vascular tone. Low PI peripheral vasoconstriction with or without severe hypovolemia, and high PI generally indicates dilation of peripheral blood vessels (29).The PVI maintains monitoring of continuous, noninvasive dynamic follow-up of circulating blood volume and has been pointed out to assess fluid resuscitation (30). PVI is a better predictor of the dynamic alterations in the PI that may occur in the course of respiratory cycles (31). The PVI is a beneficial technique due to its advantages, such as being noninvasive characteristic , utilizing a feasible to attach an sensor, and its providing of continuous bedside evaluation method (32). Coeckelenbergh et al. (33) pointed out that PVI was a better predictor for appropriate fluid therapy similarly to pulse pressure alterations due to the length of hospital stay and incidence of postoperative complications in cases, particularly following low-to-moderate-risk abdominal surgery.

Kumar et al. (34) defined changes in the PI value as an outcome of local vasoconstriction (low PI) or vasodilation (increased PI) in the skin. Anxiety that occurs before spinal anaesthesia causes alterations in blood pressure, PVI and PI due to an increase in sympathetic tone. To minimise this, we allowed patients to rest and supported them to remain calm prior to the measurement of hemodynamic variables. Sympathetic block levels are higher than sensory block levels during spinal anaesthesia.

There are some limitations to our study. First, the presence of spontaneous breathing and the patient's stress, anxiety and movement may have affected the PI values. In addition, increased sympathetic activation after spinal block and vasoconstriction in unblocked areas and changes with PI.

CONCLUSION

In conclusion, 0.9% NaCl and gelatine were more effective on PI in caesarean section under spinal anesthesia. Isotonic has a positive effect on both PI and PVI. We detected that PI increased compared to baseline values, and believe that this increase may a positive effect on tissue circulation in the patient.

ETHICAL DECLARATIONS

Ethics committee approval: The study was carried out with the permission of Malatya Turgut Ozal University Clinical Researches Ethics Committee (Decision No: 2021/65).

Informed consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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