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Comparison of the effects of two different local anesthetics used in spinal anesthesia on peripheral and central temperature change: a randomized controlled trial

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Abstract

Objective In this study, we aimed to compare the effects of two different local anesthetics with different baricity used in spinal anesthesia on thermoregulation.

Materials and methods Our study was conducted on forty full-term pregnant women scheduled for elective cesarean sections under spinal anesthesia. At an operating room temperature of twenty-four degrees Celsius, peripheral body temperature was measured using temperature probes attached to the lower medial parts of the same side's lower and upper extremities, and central body temperature was measured with a tympanic thermometer. Isobaric levobupivacaine and hyperbaric bupivacaine were used in spinal anesthesia applications. After spinal anesthesia, tympanic temperature, arm and leg temperatures, mean arterial pressure, heart rate, and oxygen saturation were measured and recorded at baseline, the first, third, and fifth minutes, and every five minutes thereafter until the end of surgery.

Results In the bupivacaine group, a decrease in tympanic temperature was observed at the third minute and an increase in leg skin temperature at the fifth minute compared to baseline values. In the levobupivacaine group, a decrease in tympanic temperature was observed at the fifth minute, and an increase in leg skin temperature was observed at the third minute. In both groups, within-group comparisons showed a continued decrease in tympanic temperature and increase in leg temperature at all subsequent time points compared to baseline. No statistically significant difference was observed in arm skin temperatures within groups in either group.

Conclusion We observed that the effects of hyperbaric bupivacaine and isobaric levobupivacaine used in spinal anesthesia on thermoregulation were similar.

Keywords Spinal anesthesia, Local anesthetics, Thermoregulation, Baricity

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Introduction

Spinal anesthesia is widely accepted today as a safe method used in many operations, especially in lower abdominal and extremity surgeries. Recent meta-analyses have further confirmed its safety profile, even in high-risk populations such as elderly patients undergoing hip fracture repair, though careful monitoring of hemodynamic changes remains essential.Moreover, the safety and effectiveness of spinal anesthesia depend on the correct selection and appropriate use of local anesthetics [1]. It is not widely known that spinal anesthesia causes fluctuations in body temperature as much as, or even more than, general anesthesia. There is a lot of literature showing that the temperature decrease in regional anesthesia is similar or even greater than in general anesthesia [2, 3]. Much of knowledge about hypothermia during regional anesthesia could be based on thelack of monitoring in these patients. It could serve as a justification to carry out clinical trials in patients under regional anesthesia [4–7]. In patients undergoing spinal or epidural anesthesia, as in general anesthesia, the primary cause of hypothermia is the redistribution of body heat. Neuroaxial anesthesia centrally inhibits thermoregulatory control but has a much more significant effect by blocking peripheral and motor nerves that prevent thermoregulatory vasoconstriction and shivering [8–13]. The redistribution that continues during neuroaxial anesthesia is typically limited to the legs. The weight of the legs far exceeds that of the arms and thus contributes much more significantly to redistribution [14].

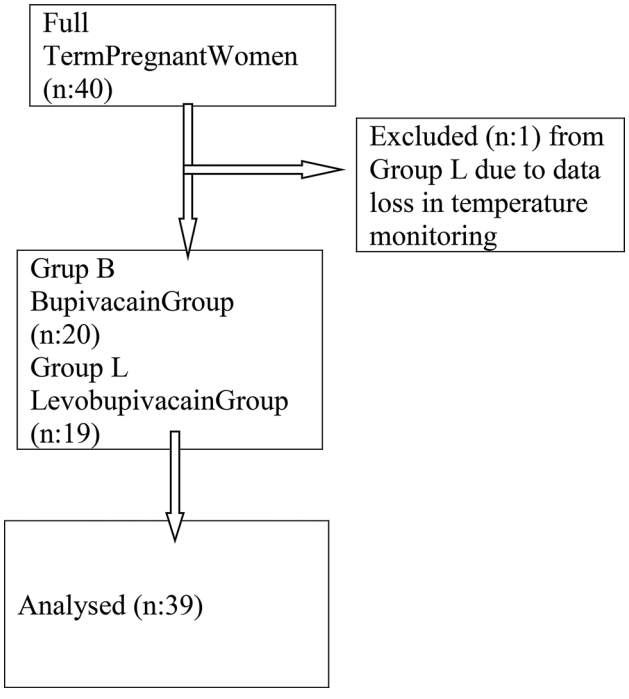

Fig. 1 Study Design

Isobaric levobupivacaine and hyperbaric bupivacaine are agents frequently used in spinal anesthesia. Comparative studies have been conducted with various doses in many types of operations [15–18]. Although there are numerous in vitro studies showing changes in local anesthetic densities at different temperatures, we found very few studies demonstrating the clinical effects of these changes [19–23]. The effect of temperature is particularly pronounced in diluent solutions; for example, 0.5% bupivacaine and levobupivacaine are slightly hyperbaric at room temperature (20–24 °C) and slightly hypobaric at body temperature (30–37 °C) [23–25]. Therefore, these changes in baricity lead to variations in the spread of local anesthetics within the cerebrospinal fluid (CSF) and affect the level of motor and sensory block.

Previous comparative studies have been conducted on the effects of regional and general anesthesia on core and skin temperatures. However, we did not find any studies comparing the effects of local anesthetics with different baricities on body temperatures. In this study, we aimed to compare the effects of two local anesthetics with different baricities, hyperbaric bupivacaine and isobaric levobupivacaine, on central and peripheral body temperatures in patients undergoing spinal anesthesia and the potential influence of the baricity of the local anesthetic in decreasing the extent of the blockade of the sympathetic nervous system and thus decreasing the extent of the vasodilation caused.

Materials and methods

After obtaining approval from the Fatih University Faculty of Medicine Ethics Committee, at 21.02.2014 with code number 33/5, our study was comply with the principles of the Declaration of Helsinki and conducted on 40 full-term pregnant women aged 18–40, classified as ASA I-II, who were scheduled for elective cesarean sections under spinal anesthesia. All patients included in the study were informed and gave their written and verbal consent 2 h before the surgery.

Our study was planned as a mono centric, prospective, randomized, double-blind trial. A computer-generated random sequence was used for allocation. The groups were divided into the bupivacaine group (Group B) and the levobupivacaine group (Group L) (Fig. 1). Neither the physician nor the patient knew which group they are in. Another physician enrolled participants, and who assigned participants to interventions.

Exclusion criteria were patients for whom spinal anesthesia was contraindicated, those with neuromuscular diseases, alcohol and substance abusers, patients with a body mass index (BMI) < 18.5 kg/m² or > 35 kg/m², those using medications that could affect thermoregulation such as vasodilators, patients with thyroid disorders,

those with fever and infection, and expectant mothers known to have allergies to the study drugs.

For all patients brought to the operating room, an intravenous line was established using a 22-gauge catheter on the dorsum of the hand, and an infusion of room-temperature Ringer's lactate at 10 ml/kg was initiated to be administered over half an hour before spinal anesthesia. The operating room temperature was maintained at a constant 24 °C, monitored by an electronic temperature monitor. Blood pressure was monitored using a non-invasive automatic sphygmomanometer, heart rhythm was monitored with a five-lead electrocardiogram (ECG), and peripheral oxygen saturation was monitored with a pulse oximeter. Temperature probes (Philips temperature probes, Biyoplus Medical TM, Yalova) attached to the lower medial parts of the same side's lower and upper extremities were used to measure peripheral body temperature, and a tympanic thermometer (Covidien GeniusTM 2, USA) was used to measure central body temperature. All patients' external auditory canals were examined using an otoscope (Rieste, Tuttlingen, Germany), and any cerumen was removed by an ear, nose, and throat specialist. Demographic data (age, weight, height) of all expectant mothers were recorded before the block. Baseline values for mean arterial pressure (MAP), heart rate (HR), oxygen saturation (SpO2), lower and upper extremity temperatures, and tympanic membrane temperature were recorded before anesthesia.

The application was performed by a different physician, and the follow-up was conducted by another physician unaware of the application. All patients were positioned sitting. The puncture site was disinfected with a 10% povidone-iodine antiseptic solution and covered with a sterile drape. Using a 27-gauge Whitacre pencil point spinal needle (B.BraunMelsungen A.G., Germany), the spinal space was accessed through the L3-L4 or L4-L5 interspinous space, and after observing the free flow of cerebrospinal fluid (CSF), 2-2.5 ml of room-temperature hyperbaric 0.5% bupivacaine (15 ml,75 mg) (10–12,5 mg) (Marcaine® spinal heavy, 0.5%, Astra Zeneca, Istanbul) was administered to the bupivacaine group (Group B), and 2-2.5 ml (10–12,5 mg) of room-temperature 0.5% levobupivacaine (15 ml, 75 mg) (Chirocaine®, 0.5%, Abbott Laboratories, Istanbul) was administered to the levobupivacaine group (Group L). After the procedure, patients were positioned 15° supine on the left side and 30° head-up.

Sensory block was determined bilaterally using the pinprick test along the midclavicular line. The sensory block level of the patient was measured and recorded from the 3rd minute after spinal anesthesia. Once it was confirmed that an adequate block level for the operation was achieved, surgery was allowed to proceed. The patient's MAP, HR, SpO2, tympanic temperature, and peripheral temperatures from the arm and leg were measured and recorded at baseline, and then at 1, 3, and 5 min after anesthesia administration, followed by 5-minute intervals.

In cases of severe hypotension (when MAP fell below 20% of preoperative values), 10 mg of ephedrine was planned to be administered, and in cases of bradycardia (HR values below 20% of preoperative values), 0.5 mg of atropine was to be administered. Patients were asked if they experienced any complaints of cold or shivering. No sedatives, hypnotics, or narcotic drugs were administered to the patients.

Sample size: The power analysis conducted using the means and standard deviations obtained from the results of the study titled "The effect of bupivacaine with fentanyl temperature on initiation and maintenance of labor epidural analgesia: a randomized controlled study" indicated that, with a power of 80% and a significance level of 0.05, a minimum of 24 patients would need to be included in each group [26].

Statistical analysis

All statistical calculations were performed using SPSS for Windows software (Statistical Package for the Social Sciences), version 20 (SPSS Inc., Chicago, IL, USA). Parameters following a normal distribution were analyzed using the Student's t-test, while parameters not following a normal distribution were analyzed using the Mann-Whitney U test. The Friedman test was used for the comparison of variables within groups, and the Wilcoxon test was used for multiple comparisons after Bonferroni correction. Values are presented in the article, tables, and graphs as mean ± standard deviation (SD) or median (25th-75th percentiles). A p-value of < 0.05 was considered statistically significant.

Results

A total of 40 female patients scheduled for elective cesarean operations were included in our study. One patient from Group L was excluded due to data loss in temperature monitoring. The study was completed with 20 patients in Group B and 19 patients in Group L.

When comparing the groups in terms of age, height, weight, operation duration, and the dose of drugs used for spinal anesthesia, no statistically significant differences were found ($p > 0.05$) (Table 1).

No statistically significant differences were found in the comparison of HR, SpO2, and MAP between the groups ($p > 0.05$). In the intergroup comparisons of MAP measurements, a significant difference was only found in the basal values ($p = 0.024$).

In Group B, a decrease in tympanic temperature at the 3rd minute and an increase in leg skin temperature at the 5th minute compared to basal values were observed,

Table 1 Demographic data

	Group B (*n* = 20)	Group L (*n* = 19)	*P*
Age (Year)	29.3 ± 5.03	31.0 ± 3.2	0.220[a]
Height (cm)	164.6 ± 5.8	164.5 ± 6.1	0.949[a]
Weight (kg)	76.0 ± 7.4	78.0 ± 8.8	0.443[a]
Duration of operation(minute)	29.2 ± 8.1	25.0 ± 7.8	0.105[a]
Dose of Drug administered (ml)	2.4 ± 0.1	2.5 ± 0.1	0.054[a] 0.054

a: Student'st-test

which was considered statistically significant (p < 0.05) (Table 2).

In Group L, a decrease in tympanic temperature at the 5th minute and an increase in leg skin temperature at the 3rd minute compared to basal values were detected. This was considered statistically significant ($p < 0.05$) (Table 2).

In both groups, the decrease in tympanic temperature and the increase in leg temperature continued at all time points compared to the baseline in within-group comparisons, and these changes were considered statistically significant ($p < 0.05$).

When comparing the tympanic, leg, and arm temperature measurements of Groups B and L, no statistically significant differences were observed ($p > 0.05$).

When comparing the maximum changes in leg skin temperature and tympanic temperature at the 5th minute and subsequent times, no statistically significant differences were observed between the groups ($p > 0.05$) (Table 3; Fig. 2).

No statistically significant differences were observed in the within-group comparison of arm skin temperatures in both groups ($p > 0.05$) (Table 4).

In the comparison between groups, Group L was found to have a higher maximum sensory block level and a shorter time to reach maximum sensory block ($p < 0.05$). (Table 5).

During the procedure, hypotension developed in 10 patients in Group B and 11 patients in Group L, while bradycardia developed in 2 patients in Group B and 1 patient in Group L, and these were treated. None of the patients experienced coldness or shivering.

Discussion

Hypothermia can frequently occur during regional anesthesia and can be almost as severe as in general anesthesia. As in general anesthesia, the primary cause of hypothermia in patients undergoing spinal or epidural anesthesia is the redistribution of body heat.

Frank et al. investigated the causes of hypothermia in patients undergoing spinal anesthesia and found that vasomotor inhibition following spinal anesthesia resulted in blood pooling in peripheral tissues, leading to heat loss and hypothermia [25].

Table 2 Within-group comparison of tympanic and leg temperature in group B and group L

	Group B				Group L			
	Tympanic temperature	*P*	Leg temperature	*P*	Tympanic temperature	*P*	Leg temperature	*p*
Baseline	36.4 ± 0.4		29.5 ± 1.3		36.4 ± 0.3		28.9 ± 1.6	
1st minute	36.3 ± 0.5	0.186[a]	29.0 ± 2.1	0.175[a]	36.4 ± 0.3	0.938[a]	29.2 ± 1.57	0.152[a]
3rd minute	36.1 ± 0.5	0.003[a]*	29.8 ± 1.5	0.380[a]	36.3 ± 0.4	0.129[a]	29.4 ± 1.3	0.036[a]*
5th minute	36.07 ± 0.4	0.044[a]*	30.4 ± 1.4	0.001[a]*	36.1 ± 0.5	0.004[a]*	30.2 ± 1.2	0.001[a]*
10th minute	35.9 ± 0.4	0.001[a]*	31.5 ± 1.4	0.001[a]*	35.8 ± 0.3	0.001[a]*	31.1 ± 1.3	0.001[a]*
15th minute	35.8 ± 0.4	0.001[a]*	32.2 ± 1.3	0.001[a]*	35.7 ± 0.4	0.001[a]*	31.8 ± 1.8	0.001[a]*
20th minute	35.7 ± 0.4	0.001[a]*	32.3 ± 1.2	0.001[a]*	35.7 ± 0.5	0.001[a]*	32.2 ± 1.1	0.001[a]*
25th minute	35.4 ± 0.6	0.001[a]*	31.8 ± 3.0	0.002[a]*	35.6 ± 0.5	0.001[a]*	32.6 ± 1.1	0.001[a]*
30th minute	35.3 ± 0.7	0.007[a]*	32.9 ± 1.1	0.005[a]*	35.8 ± 0.4	0.009[a]*	33.3 ± 0.9	0.002[a]*

a: Student's t-test

Data are presented as mean ± SD

*$p < 0.05$ was considered statistically significant

Table 3 Comparison of tympanic and leg temperature changes between groups

	Group B (*n* = 20)	Group L (*n* = 19)	*P*
Change in leg skin temperature at the 5th minute	0.8 (-1.5–3.2)	1.3 (-0.8–3.5)	0.167[b]
Maximum change in leg skin temperature	3.6 (0.2 – 6.6)	3.8 (1.7 – 6.7)	0.771[b]
Change in tympanic temperature at the 5th minute	-0.4 (-1.1 – 0.2)	-0.3 (-1.4 – 0.5)	0.708[b]
Maximum change in tympanic temperature	-0.8 (-1.3–-0.1)	-1.1 (-1.8–-0.2)	0.113[b]

b: Mann- Whitney U Test

Data are presented as median (min-max)

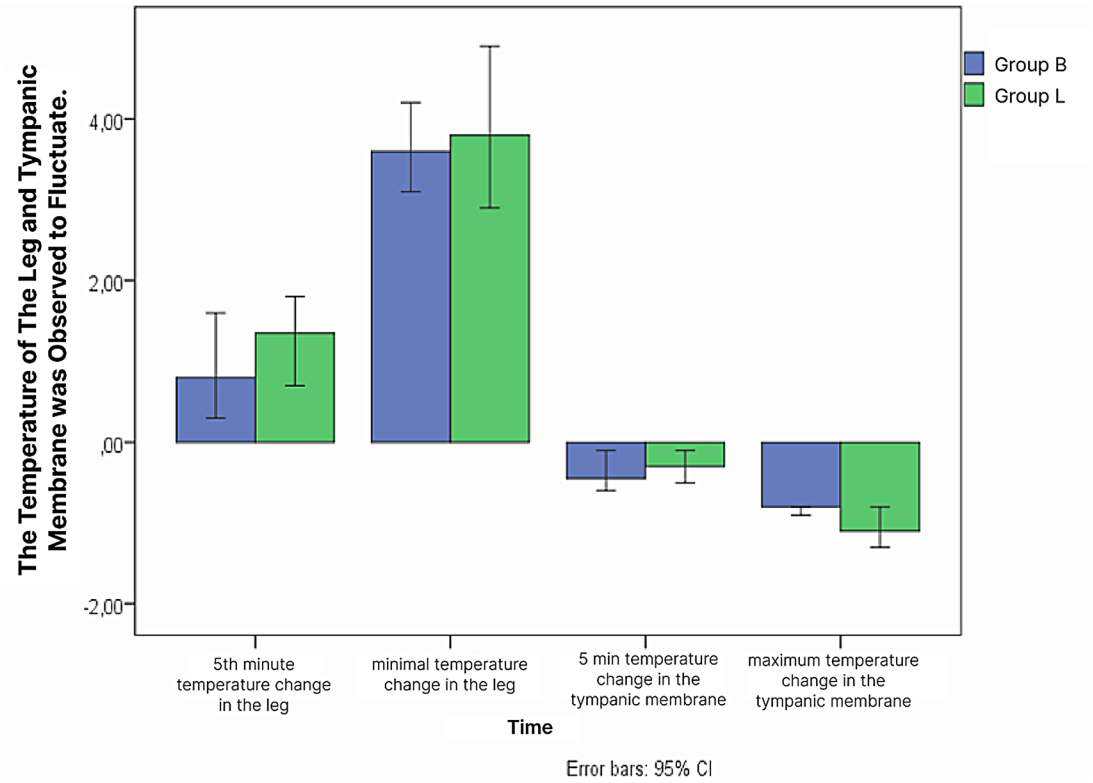

Fig. 2 Comparison of tympanic and leg temperature changes between groups

Table 4 Comparison of arm temperature changes between groups

	Group B (*n* = 20)	Group L (*n* = 19)	*P*
Baseline	33.0 ± 1.3	32.7 ± 1.8	0.579[a]
1st minute	32.8 ± 1.4	33.06 ± 1.2	0.687[a]
3rd minute	32.5 ± 1.2	32.6 ± 1.3	0.794[a]
5th minute	32.3 ± 1.5	32.6 ± 1.4	0.654[a]
10th minute	32.6 ± 1.6	32.8 ± 1.5	0.736[a]
15th minute	32.6 ± 1.4	32.9 ± 1.3	0.573[a]
20th minute	32.9 ± 1.4	32.9 ± 1.5	0.862[a]
25th minute	32.8 ± 1.5	32.9 ± 1.6	0.893[a]
30th minute	32.6 ± 1.7	33.7 ± 1.1	0,236[a]
35th minute	32.7 ± 2.1	34.7 ± 0,2	0,214[a]

a: Student's t-test

Data are presented as mean ± SD

Table 5 Comparison of sensory block characteristics between groups

	Group B (*n* = 20)	Group L (*n* = 19)	*P*
Maximum Sensory Block Level	4(3–6)	3(3–3)	0.007[b]*
Time to Reach Maximum Sensory Level (min)	7.5(3–20)	5(5–5)	0.015[b]*

b: Mann-Whitney U Test

Data are presented as median (min-max)

*$p < 0.05$ was considered statistically significant

Hypothermia occurs less frequently in regional anesthesia compared to general anesthesia. This may be due to the preservation of metabolic rate and vasoconstriction in the arms [14]. Matsukawa et al. evaluated heat redistribution under epidural anesthesia at a constant ambient temperature in 12 male volunteers. The initial hypothermia in the first hour following epidural anesthesia was mainly due to the redistribution of body heat from the internal thermal compartment to the distal legs, and it continued throughout the three-hour duration of anesthesia. It was shown that the arm heat content decreased three times more than the baseline in the three hours following epidural anesthesia. Despite the higher fractional contribution of redistribution in epidural anesthesia, it was noted that internal metabolic heat was preserved and vasoconstriction occurred in the arms, leading to less frequent temperature drops compared to general anesthesia [14]. In our study, the maximum decrease in tympanic temperature was − 0.8 (-1.3 to -0.1)°C in the bupivacaine group and − 1.1 (-1.8 to -0.2)°C in the levobupivacaine group, consistent with these studies. However, unlike the above study and their findings, the arm temperature values in our patients did not change compared to baseline.

In contrast to these studies, other studies have shown that epidural anesthesia causes a higher rate of hypothermia compared to general anesthesia [27, 28]. In a study conducted on 15 patients undergoing transvesical

prostatectomy with epidural and standard general anesthesia, internal and superficial temperatures were measured before, during, and for the first 6 h postoperatively. It was found that total and mean body temperatures dropped more rapidly in the epidural group, with statistically significant differences in the early postoperative period. In another study comparing the effects of lumbar epidural and general anesthesia on body temperatures, it was shown that the temperature drop was slower and shorter in the epidural anesthesia group, while it was faster and lasted longer in the general anesthesia group. Consequently, the number of patients with core temperatures below 35 °C was higher in those receiving general anesthesia compared to those receiving epidural anesthesia. In our study, since the operation lasted less than an hour and postoperative temperature monitoring was not performed, we could not evaluate temperature changes in the later hours.

In a study by Hopf et al. involving 53 patients undergoing high thoracic, mid-thoracic, and lumbar epidural anesthesia, bupivacaine and saline of the same volume were administered to each group to evaluate arm and leg temperatures. In the high thoracic application, it was found that temperature increased in the arms and legs of the bupivacaine group and decreased in the saline group. In the mid-thoracic injection, a significant increase in leg temperature was observed, with no change in the arms. Following lumbar injection, a significant increase in leg temperature and a decrease in arm temperature were observed. This supports the hypothesis of vasoconstriction occurring in the arms. While leg temperature changes were similar after high and mid-thoracic injections, the increase in leg temperature following lumbar injection was greater than that observed from the other two regions. This was attributed to sympathetic blockade related to the dermatomes involved. Skin temperature on the body either remained unchanged or significantly decreased in blocked areas. Assuming that increased leg temperature reflects decreased sympathetic activity, it was concluded that high and mid-thoracic segmental epidural anesthesia involving several dermatomes led to sympathetic blockade that included the most caudal part of the sympathetic nervous system [13]. In our study, following spinal anesthesia, within-group comparisons showed that all measurements over time revealed a continued decrease in tympanic temperature and an increase in leg temperature compared to baseline. The maximum change in leg skin temperature increased by + 3.6 (+ 0.2–+6.6)°C in the bupivacaine group and by + 3.8 (+ 1.7–+6.7)°C in the levobupivacaine group, with no statistically significant difference observed between the groups.

Unlike the studies mentioned above, no difference was detected in arm temperature measurements compared to baseline in our study. This could be due to the numerous factors affecting hypothermia andas well as the fact that our patients were term pregnant.

In a large randomized study by Frank et al. investigating the effects of ambient temperature on hypothermia, 97 patients undergoing lower extremity vascular surgery with general and epidural anesthesia were included. It was observed that there was a significant relationship between operating room ambient temperature and type of anesthesia, with greater body temperature drops occurring with general anesthesia in the cold ambient temperature, but similar drops in warm ambient temperature with both general and epidural anesthesia [29].

Some studies have shown that hypothermia is also related to the patient's thermal condition and can be corrected by warming the skin before anesthesia induction. It was found that the drop in core temperature during epidural anesthesia was less in the warmed group. As a result, it was shown that preoperative warming reduced redistribution hypothermia during epidural block [29, 30]. In our study, to eliminate the effects of ambient temperature, the operating room temperature was kept constant at 24 °C for all patients. Additionally, 10 ml/kg of room-temperature Ringer's lactate was administered intravenously over half an hour before spinal anesthesia to minimize related changes.

In a study by Goktuğ et al. on patients undergoing inguinal hernia surgery with spinal anesthesia, bupivacaine and levobupivacaine were compared in terms of blood pressure, pulse, motor block status, sensory block level, VAS values, and side effects. The onset time of sensory block was found to be significantly shorter in the levobupivacaine group compared to the bupivacaine group. When examining hemodynamic changes, no significant difference was found between the two groups [31]. In our study, the hemodynamic data, sensory and motor block onset times, and characteristics evaluated during the operation were consistent with other studies [16–18].

Esophageal temperature measurement is known to be the safest method for monitoring core temperature. Studies have shown that under stable conditions, there is a significant correlation between tympanic and esophageal temperatures [32–34]. In our study, we did not prefer esophageal temperature measurement for patients undergoing regional anesthesia, considering it to be invasive. Instead, we used tympanic membrane temperature measurement for core temperature monitoring. For peripheral temperature measurements, we used the forearm and calf temperatures. Due to the effect of subcutaneous fat tissue on heat distribution, we did not include patients who were very thin (body mass index < 18.5 kg/m^2) or very obese (body mass index > 35 kg/m^2) in our study. There was no significant difference between the

two groups in terms of height, weight, and body mass index.

Pregnancy is known to alter both the normal thermoregulatory response and the anesthetic response [34–36]. Only term pregnant patients were included in our study, so changes due to pregnancy were applicable to both groups.

While there are in vitro studies demonstrating changes in the density of local anesthetics at different temperatures, we found few studies demonstrating the clinical effects of these changes [19–23]. McLeod used the mechanical oscillation resonance method to investigate the relationship between temperature and density, showing that densities at 37 °C (0.99944 for 0.5% bupivacaine, 1.00024 for 0.5% levobupivacaine, and 0.99953 mg/mL for 0.5% ropivacaine) were lower than those at 23 °C [37]. The effect of temperature is particularly pronounced in diluent solutions; for example, 0.5% bupivacaine and levobupivacaine are slightly hyperbaric at room temperature (20–24 °C) and slightly hypobaric at body temperature (30–37 °C) [23, 24]. In light of these studies, we can say that the local anesthetic drugs we used were slightly hypobaric instead of hyperbaric and isobaric at body temperature, affecting core body temperature in the same direction as baricity.

The limitations of our study include not calculating the basal temperature of the patients, absence of esophageal thermometer, not performing postoperative temperature monitoring and being a monocentric study.While all of the patients were pregnant, the study was carried out on women and there fore the application of the findings is not extensible too ther populations such as men, children or the elderly. The last limitation of our prospective study is conducted in 2014, did not receive a Clinical Trial Number, as it was not obtained at that time.

Conclusion

In conclusion, in our study evaluating central and peripheral temperatures following spinal anesthesia with isobaric levobupivacaine and hyperbaric bupivacaine, there was no difference between the groups in terms of the maximum increase in peripheral temperature and the level of central temperature decrease. We believe that adequate monitoring and precautions should be taken to avoid hypothermia, especially in long surgeries and at-risk groups, following spinal anesthesia.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-025-03148-1.

Supplementary Material 1

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Author contributions
A.O., G.E.D., M.D. conception or design of the work. A.K., O.M., Y.D. acquisition, analysis, interpretation of data. H.K., B.M., Se.K., Sa.K. interpretation of data. A.O., G.E.D. drafting the work and reviewing.

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Data availability
The data sets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval for this study (decision number: 33/5) was provided by the Ethical Committee Turgut Ozal University Hospital, Ankara, Turkey on 21 February 2014.

Consent for publication
Written informed consent for the publication of data was obtained from all individuals participating in the study.

Compliance with ethical standards
All the authors mentioned in the manuscript have agreed for authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript. The manuscript in part or in full has not been submitted or published anywhere.

Competing interests
The authors declare no competing interests.

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