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ORIGINAL ARTICLE

Comparison of the Effects of Tumescent Anesthesia Applied at Two Different Temperatures on Recovery After Liposuction Surgery

İki Farklı Sıcaklıkta Uygulanan Tümescent Anestezisinin Liposuction Ameliyatları Sonrası Derlenme Üzerine Etkilerinin Karşılaştırılması

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ABSTRACT

Aim: This randomized clinical study aimed to evaluate the effects of tumescent solution temperature on patient outcomes
Methods: A total of 35 ASA I–II female patients aged 18–65 undergoing liposuction were divided into two groups: Group A (n=17) received room-temperature (20–22°C) tumescent solution, while Group B (n=18) received warmed (30–36°C) solution. Standard general anesthesia was applied, and both groups underwent similar procedures with body temperature, hemodynamics, pain, recovery, and side effects monitored postoperatively.
Results: Intraoperative and early postoperative body temperatures were significantly higher in the warmed solution group ($p<0.05$). Postoperative shivering (22.2% vs. 82.4%) and subjective cold sensation (16.7% vs. 70.6%) were significantly lower in Group B ($p<0.05$). Additionally, pain during the recovery phase and narcotic analgesic requirement were significantly lower in the warmed group (11.1% vs. 52.9%, $p<0.05$). No significant differences were found between the groups in terms of mean arterial pressure, heart rate, oxygen saturation, nausea, vomiting, or first analgesic timing.
Conclusions: The study concludes that warming the tumescent solution improves thermal stability, reduces discomfort from shivering, decreases postoperative pain and narcotic use, and enhances patient satisfaction. These findings support the routine use of warmed infiltration solution (30–36°C) in liposuction to optimize postoperative recovery and patient safety.

Keywords: Liposuction, tumescent anesthesia, warmed solution, postoperative pain, hypothermia, patient recovery.

ÖZ

Amaç: Liposuctionda tumescent solüsyon sıcaklığının hasta sonuçları üzerindeki etkilerini değerlendirmeyi amaçladık.
Gereç ve Yöntemler: Bu randomize klinik çalışmada, Liposuction geçiren 18-65 yaş arası toplam 35 ASA I–II kadın hasta iki gruba ayrılmıştır: Grup U'ya (n=17) oda sıcaklığında (20–22°C) tumescent solüsyon, Grup H'ye ise (n=18) ısıtılmış (30–36°C) solüsyon uygulanmıştır. Hastalara standart genel anestezi uygulanmış ve her iki grup da vücut sıcaklığı, hemodinamik, ağrı, iyileşme ve yan etkiler postoperatif olarak izlenerek kaydedilmiştir.
Bulgular: Intraoperatif ve erken postoperatif vücut sıcaklıklarının ısıtılmış solüsyon grubunda önemli ölçüde daha yüksek olduğunu göstermiştir ($p<0,05$). Ameliyat sonrası titreme (%22,2'ye karşı %82,4) ve öznel soğuk hissi (%16,7'ye karşı %70,6) Grup U'de önemli ölçüde daha düşüktü ($p<0,05$). Ek olarak, iyileşme evresindeki ağrı ve narkotik analjezik gereksinimi ısıtılmış grupta önemli ölçüde daha düşüktü (%11,1'e karşı %52,9, $p<0,05$). Ortalama arter basıncı, kalp hızı, oksijen satürasyonu, mide bulantısı, kusma veya ilk analjezik zamanlaması açısından gruplar arasında önemli bir fark bulunamadı.
Sonuçlar: Tumescent solüsyonunun ısıtılmasının termal stabiliteyi iyileştirdiği, titremeden kaynaklanan rahatsızlığı azalttığı, ameliyat sonrası ağrıyı ve narkotik kullanımını azalttığı ve hasta memnuniyetini artırdığı sonucuna varılmıştır. Bu bulgular, ameliyat sonrası iyileşmeyi ve hasta güvenliğini optimize etmek için liposuction'da ısıtılmış infiltrasyon solüsyonunun (30–36°C) rutin kullanımını desteklemektedir.

Anahtar Kelimeler: Anestezi, Hipotermi, Liposuction, Postoperatif ağrı, Vücut Sıcaklığı,

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INTRODUCTION

Liposuction surgeries today constitute the majority of plastic surgery cases. These procedures are highly popular in plastic surgery and continue to attract growing interest. Although the technique is relatively simple, complications may occasionally be observed (1). These complications may include hypothermia, acidosis, bleeding, micro-level fat embolism, pulmonary embolism, pulmonary edema, intra-abdominal organ injury, perforation, prolonged recovery, fluid overload, and toxicity from adrenaline and local anesthetic agents. Subcutaneous emphysema is also a known but infrequent complication of liposuction (2). The techniques used in liposuction vary. One of the most commonly used methods is tumescent anesthesia infiltration (3). Tumescent liposuction is a tissue-preserving method that removes fat cells while causing less trauma to the surrounding tissues (4). In liposuction surgeries, the tumescent anesthesia solution is administered to the adipose tissue via a cannula before the surgery begins. The purpose of this fluid application is to reduce bleeding, minimize the risk of fat embolism, and prevent the cannula from reaching internal organs, thereby avoiding internal organ damage. Tumescent liposuction and surgical excision have been proven to be safe and effective treatment options, providing cosmetic results with minimal scarring (5). When the tumescent liposuction technique is applied, the main factor contributing to the decrease in body temperature during the intraoperative and early postoperative period is the injection of cold solutions into the subcutaneous tissues. In liposuction surgeries, tumescent anesthesia solutions are typically administered at room temperature (20–22°C) in the operating room. During surgery, several factors contribute to a drop in body temperature: the low ambient temperature of the operating room, the infusion of intravenous fluids at room temperature, the use of antiseptic solutions stored at room temperature for surgical preparation, insensible heat loss, and the infiltration of tumescent solution at room temperature. These conditions can lead to postoperative hypothermia, shivering, acidosis, and delayed recovery. As a result, hypothermia, acidosis, disruption of the coagulation cascade, increased bleeding, and arrhythmias may occur, ultimately increasing mortality (6). Therefore, various strategies are used to prevent hypothermia, such as warming the patient, maintaining a warm operating room, and heating intravenous and tumescent solutions. However, patient warming and medical interventions may delay discharge.

The aim of the study is to compare the hemodynamic changes, postoperative recovery, shivering, bleeding, hypothermia, postoperative pain, recovery duration, and discharge times in liposuction procedures performed using tumescent solutions kept at room temperature versus those kept at body temperature.

MATERIALS and METHODS

Patients were evaluated after approval was obtained from the Istanbul Atlas University Clinical Research Ethics Committee (Decision No: 02.03.2023-24607). The study was conducted under the principles of the Declaration of Helsinki.

Before surgery, patients underwent routine preoperative anesthesia assessment. After obtaining informed consent for anesthesia

and surgery, standard monitoring was initiated in the operating room, followed by induction of anesthesia, intubation, and commencement of the surgical procedure. All patients underwent general anesthesia administered by the same anesthesiologist using a standard induction protocol. Intraoperative bleeding and body temperature were recorded.

Two groups were formed, each consisting of healthy patients aged 18 to 65 years who were undergoing liposuction surgery. Group H: The study group received infiltration with heated tumescent solution (30–36°C). Group U: The control group received tumescent infiltration at room temperature, unheated (20–22°C). Due to patient refusal, one individual was excluded from Group H. As a result, the control group (Group U) consisted of 18 healthy female patients, while the study group (Group H) included 17 healthy female patients. A simple randomization method was employed.

An intraoperative warming mattress was used for all patients. During surgery, the amount of bleeding and the patient's body temperature were recorded. Before awakening from anesthesia, standard postoperative analgesia was administered. After the patients regained consciousness, body temperature, shivering, bleeding volume, pain level, pain score was evaluated Postoperative Pain Scores, Pain score was assessed with a five point VAS (Visual Analog Scale) (No pain=0, very mild pain=1, mild pain:2, moderate pain:3, severe pain=4) and vital signs were documented in the liposuction follow-up form in the postoperative recovery room. The same protocol was applied to all patients. Once fully recovered, patients were transferred to the ward. Vital signs and pain scores were recorded at the second, sixth, 12th, 24th, and 48th hours postoperatively.

Inclusion criteria were ASA I–II patients aged 18 to 65 years undergoing liposuction surgery. Exclusion criteria included: ASA III–IV patients, COVID-19 positive status, uncontrolled hypertension, history of thromboembolism, fat embolism, or myocardial infarction within the last 6 months, severe renal or hepatic disease, uncontrolled diabetes mellitus, liver enzyme levels more than twice the normal limit, obstructive sleep apnea, moderate to severe chronic obstructive pulmonary disease, neurological or major psychiatric disorders, and patients taking medications that could affect thermoregulation. Tumescent solutions were heated using a mini autoclave fluid warmer for three–five minutes and then administered at the target temperature. After warming, solutions were prepared by mixing epinephrine, bicarbonate, and local anesthetics. Body temperature was measured every five minutes preoperatively and postoperatively using a DT-8806C infrared skin thermometer. Pulse rate, respiratory rate, and non-invasive arterial blood pressure were also measured every five minutes. Liposuction was performed on the abdomen, flanks, back, thighs, and arms in both groups. All patients underwent general anesthesia. The infiltration solution consisted of 0.9% normal saline, 1 mg of epinephrine, 8.4 mEq of bicarbonate, and 200 mg of bupivacaine. Infiltration was performed using 2.5 mm cannulas connected to a Randolph Econ II Vari-Flow pump. All solutions were prepared by the same individual and administered by the same plastic surgeon. Liposuction was performed according to patient-specific needs using the Cosmetech SSB-

IV liposuction machine. The infiltration was applied symmetrically to various body regions. All results were statistically analyzed using the Wilcoxon test and Mann-Whitney U test, and reported as means with standard deviations (SD); a p-value of <0.05 was considered statistically significant.

Statistical Method

Descriptive statistics of the data included mean, standard deviation, median, minimum, maximum, frequency, and ratio values. The distribution of the variables was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. For independent quantitative data showing normal distribution, the independent samples t-test was used. For independent quantitative data not showing normal distribution, the Mann-Whitney U test was applied. The chi-square test was used for the analysis of qualitative independent data, and when the conditions for the chi-square test were not met, the Fisher's exact test was utilized. The analyses were performed using the SPSS version 28.0 software.

RESULTS

Although the age of patients in the group that received heated tumescent solution (Group H) was statistically lower than that of the group that received unheated tumescent solution (Group U), this difference was not considered clinically significant due to randomization, and cannulation was not deemed significant ($p<0.05$). There were no significant differences between Group H and Group U in terms of weight, height, and BMI values ($p>0.05$) (Table 1). ASA scores also did not show any significant difference between the two groups ($p>0.05$). The duration of anesthesia was not significantly different between Group H and Group U ($p>0.05$) (Table 1). There was no significant difference in the volume of tumescent fluid used between the two groups ($p>0.05$). The

Table 1. Demographics of patients.

Patient Values	Group U (n=17)		Group H (n=18)		p
	mean.±Sd/%	median	mean.±Sd/%	median	
Age	42.5±11.5	41.0	32.9±8.3	32.5	0.008
Weight	69.9±11.1	69.0	73.7±11.8	72.5	ns
Height	167.5±6.2	169.0	168.3±8.2	170.0	ns
BMI	25.0±4.5	23.9	26.0±3.6	25.6	ns
ASA Score I	41.2%	7	44.4%	8	
ASA II Score	50.0%	10	50.0%	10	
First Analgesic Time (Hour)	5.6±4.7	4.0	4.9±4.9	2.0	ns
Patient Dissatisfied	23.5%	4	0.0%	0	ns
Patient Satisfaction	76.5%	13	100.0%	18	
Duration of Anesthesia (Minutes)	232.4±113.0	190.0	282.2±112.4	270.0	ns
Intraoperative Fluid Amount	2947.1±942.2	3000.0	3583.3±844.5	4000.0	0.047
Tumescent Fluid Amount	4300.0±1510.0	4000.0	4205.6±1178.0	4000.0	ns
Fluid Temperature	22.2±1.4	21.9	27.1±0.6	27.0	0.0001

Group U: Liposuction tumescent unheated, Group H: Liposuction tumescent heated. Data are presented as the number of patients (n) and percent (%). $p<0.05$ = significant. Sd= standard deviation, ns=non-significant.

time to first analgesic administration did not differ significantly between Group H and Group U (p>0.05) (Table 1).

Patient satisfaction was significantly higher in the heated tumescent liposuction group (Group H) compared to the unheated tumescent liposuction group (Group U) (p<0.05) (Figure 1).

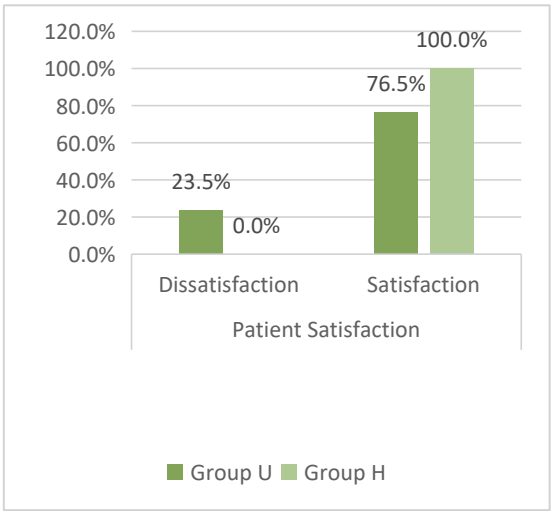

Figure 1. Patient Satisfaction
Group U: Liposuction tumescent unheated, Group H: Liposuction tumescent heated.

Preoperative, postoperative second hour, and 24th hour body temperatures showed no significant difference between Group H and Group U (p>0.05). However, intraoperative, recovery period, postoperative sixth hour, and 12th hour body temperatures were significantly higher in Group H compared to Group U (p<0.05) (Figure 2).

The postoperative use of narcotic analgesics was significantly lower in Group H compared to Group U (p<0.05) (Table 2). The incidence of postoperative shivering was also significantly lower in Group H than in Group U (p<0.05) (Table 2). There were no significant differences between the groups in terms of postoperative hypotension, bradycardia, or tachycardia rates (p>0.05). Similarly, the incidence of postoperative nausea did not differ significantly between the groups (p>0.05) (Table 2).

Postoperative pain rates were significantly lower in Group H compared to Group U (p<0.05) (Table 3). However, there was no

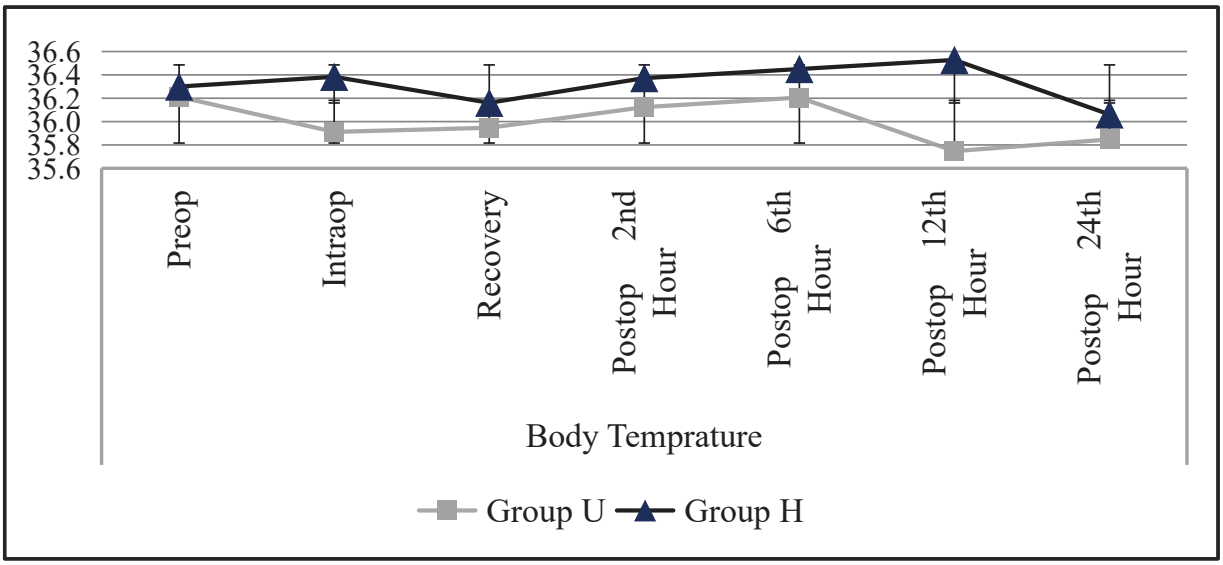

Figure 2. Patient Body Temperature
Preop: Preoperative, İntraop: İntraoperative, Postop second Hour: Postoperative second hour, Postop sixth Hour: Postoperative sixth hour, Postop 12th Hour: Postoperative twelfth hour, Postop 24th Hour: Postoperative twenty-fourth hour. Group U: Liposuction tumescent unheated, Group H: Liposuction tumescent heated.

Table 2. Postoperative values of patients

	Group (n:17) n (%)	Group H (n:18) n (%)	p
Narcotic Use	9 (52.9)	2 (11.1)	0.008
Shivering	12 (70.6)	3 (16.7)	0.001
Hypotension	2 (11.8)	1 (5.6)	ns
Bradycardia	2 (11.8)	0 (0.0)	ns
Tachycardia	2 (11.8)	0 (0.0)	ns
Vomiting	2 (11.8)	2 (11.1)	ns

Group U: Liposuction tumescent unheated, Group H: Liposuction tumescent heated. Data are presented as the number of patients (n) and percentage (%). p<0.05 = significant, ns=non significant.

Table 3. Postoperative Pain Scores

	Postoperative Pain	Group U (n=17), n(%)	Group H (n=18), n(%)	p
Recovery Room	No pain	4(23.5)	12(66.7)	**0.010**
	Very mild pain	9(52.9)	422.2)	
	Mild pain	4(23.5)	2(11.1)	
	Moderate	0(0.0)	0(0.0)	
	Severe	0(0.0)	0(0.0)	
Second Hour	No pain	7(41.2)	9(50.0)	ns
	Very mild pain	1(5.9)	4(22.2)	
	Mild pain	7(41.2)	3(16.7)	
	Moderate	1(5.9)	2(11.1)	
	Severe	1(5,9)	0(0.0)	
Sixth Hour	No pain	7(41.2)	9(50.0)	ns
	Very mild pain	6(35.3)	4(22.2)	
	Mild pain	3(17.6)	1(5.6)	
	Moderate	1(5.9)	4(22.2)	
	Severe	0(0.0)	0(0.0)	
12th Hour	No pain	7(41.2)	12(66.7)	ns
	Very mild pain	7(41.2)	4(22.2)	
	Mild pain	3(17.6)	1(5.6)	
	Moderate	0(0.0)	1(5.6)	
	Severe	0(0.0)	0(0.0)	
24th Hour	No pain	9(52.9)	13(72.2)	ns
	Very mild pain	7(41.2)	3(16.7)	
	Mild pain	1(5.9)	2(11.1)	
	Moderate	0(0.0)	0(0.0)	
	Severe	0(0.0)	0(0.0)	
48th Hour	No pain	13(76.5)	15(83.3)	ns
	Very mild pain	4(23.5)	2(11.1)	
	Mild pain	0(0.0)	1(5.6)	
	Moderate	0(0.0)	0(0.0)	
	Severe	0(0.0)	0(0.0)	

Group U: Liposuction tumescent unheated, Group H: Liposuction tumescent heated. Data are presented as the number of patients (n) and percentage (%). p<0.05 = significant, ns=non significant.
Postoperative Pain Scores, Pain score was evaluated with VAS. (No pain=0, very mild pain=1, mild pain:2, moderate pain:3, severe pain=4).
VAS: Visual Analog Scale.

statistically significant difference in pain scores between the groups at postoperative second, sixth, 12th, 24th, and 48th hours ($p>0.05$) (Table 3).

DISCUSSION

Today, liposuction is one of the most frequently performed procedures by plastic surgeons (7). It is also considered a significant operation in terms of patient safety and morbidity-mortality (8). This study was conducted to evaluate the effects of the temperature of the infiltration solution applied before the liposuction procedure on postoperative shivering, pain levels, and the amount of bleeding during surgery. However, research on this topic remains limited. Notably, no studies investigating the temperature of tumescent fluid in Turkey were found.

Our findings demonstrated that patients who received warmed solutions (30–36°C), closer to body temperature, experienced significantly less shivering, lower pain scores, and reduced blood loss compared to those who received room temperature solutions. Literature reports that administering intravenous fluids at low temperatures may cause thermoregulatory disturbances, peripheral vasoconstriction, and shivering in patients. Our study is supported by the work of Kaplan et al., who found that liposuction performed with solutions warmed to 40°C resulted in significantly lower pain scores. They recommend warming the local anesthetic solution in all tumescent liposuction procedures, as it substantially reduces the patient's perceived pain (9).

However, Pruksapong et al. (10) claimed that using cold tumescent solutions in low-volume liposuction (<1000 mL) significantly improved outcomes by reducing intraoperative blood loss, postoperative bruising, and pain, without causing short-term complications. Still, it should be emphasized that their study was conducted on low-volume liposuction procedures.

In our study, the use of cold infiltration solutions was observed to increase both the frequency and severity of postoperative shivering. In terms of pain levels, the solutions applied at body temperature were associated with lower VAS scores. This may be attributed to the less traumatic impact of warm solutions on tissue and their positive effects on local circulation. Regarding intraoperative blood loss, a significant reduction was detected in the warmed solution group. This can be interpreted as enhanced infiltration at the surgical dissection level due to vasodilation, aiding in bleeding control. A limitation of our study was the relatively small sample size.

Hypothermia, defined as a core body temperature below 36.5°C, has rarely been investigated in relation to liposuction. Hypothermia can lead to arrhythmias and even cardiac arrest. For this reason, many anesthesiologists and surgeons have investigated various methods to prevent or mitigate hypothermia. The proven effectiveness of hypothermia prevention in reducing blood loss has led to its widespread implementation in various surgical operations. In patients undergoing liposuction, further studies are needed to assess the efficacy of different methods and agents in minimizing intraoperative blood loss (6). Health tourism is a rapidly growing sector. Low costs, all-inclusive vacation packages that include plastic surgery, globalization, and affordable airfare have encouraged patients to seek

aesthetic procedures in different countries. Cosmetic medical tourism is associated with high complication rates, including serious infections, wound dehiscence, pain or discomfort, dissatisfaction with cosmetic results, and even death (11). Fat embolism syndrome has been reported to develop on the first day following breast reduction liposuction and is actually a rare but potentially life-threatening complication associated with soft tissue trauma and long bone fractures, as seen in large-volume liposuction and other cosmetic surgeries (12). The drawback of their studies is considered to be that the small amount of tumescent fluid used may not have had a significant impact on body temperature. Chia et al. (13) performed radiofrequency-assisted liposuction following tumescent injection in 300 cases and reported no significant complications or deaths. Non-surgical fat reduction methods include cryolipolysis, radiofrequency lipolysis devices, and ultrasonographic techniques. Ultrasound-assisted liposuction (UAL) can also be used in the treatment of gynecomastia (14). Cryolipolysis uses cold temperatures to induce lipolysis, while radiofrequency lipolysis devices use heat to destroy adipose tissue. Non-thermal, low-intensity, low-frequency ultrasound uses mechanical means to destroy fat cells, whereas high-intensity focused ultrasound uses thermal mechanisms. Body contouring procedures can be performed alone or in combination with other techniques (15). The J-Plasma technique, a relatively new approach in liposuction, offers high patient satisfaction and may serve as a good option for patients seeking to improve thigh contour. In a study conducted by Tambasco et al., patient satisfaction with J-Plasma in thigh aesthetics was reported to be very high, with both patients and surgeons reporting favorable outcomes (16). While small-volume liposuction can be performed under local anesthesia, large-volume liposuction requires general anesthesia. Since large volumes of tumescent fluid are injected into the subcutaneous tissue, fluid management during surgery must be carefully titrated in conjunction with hemodynamic monitoring and temperature control. Assessment of blood loss can be challenging due to its mixing with aspirated fat. As most obese patients prefer liposuction as a rapid method for weight loss, all obesity-related concerns should be addressed during the preoperative evaluation (17).

Wang et al. (18) reported that tumescent infiltration solutions at room temperature (25°C) can reduce body temperature and increase surgical risk. It is therefore recommended to use tumescent infiltration solutions at body temperature (37°C) in liposuction procedures, which supports the findings of our study. In a study conducted by Yang et al. (19), it was stated that warm tumescent solution injections cause significantly less pain in patients compared to tumescent solution injections at room temperature. Preheating the tumescent solution before surgery is an effective method for reducing pain. Robles-Cervantes et al. reported that although the temperature of the infiltration solution causes a significant change in body temperature, this change does not have a significant effect on intraoperative hemodynamic values. However, they noted that it may have a more substantial impact in patients with higher surgical risk (20). The limitations of the study include the relatively

small number of patients and the fact that, although the solution was heated to 30–36°C, its temperature dropped to 27°C in the operating room environment before being injected into the patient.

In conclusion, warming the liposuction infiltration solution contributes to more stable vital signs, accelerates postoperative recovery, reduces shivering, postoperative pain, and enhances patient comfort. The results of this study indicate that the temperature of the infiltration solution used before liposuction has a significant impact on patient comfort and surgical outcomes. The use of warmed solutions close to body temperature reduces the frequency and severity of postoperative shivering, lowers pain levels, and decreases intraoperative blood loss. Infiltration solutions administered at an appropriate temperature in liposuction and similar elective surgeries increase patient satisfaction and contribute to surgical success. Therefore, it is recommended that infiltration solutions be warmed to 30–36°C.

Conflict of Interest

The authors have no conflicts of interest to declare.

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