Effects of Isothermic Irrigation on Core Body Temperature During Endoscopic Urethral Stone Treatment Surgery Under Spinal Anesthesia: A Randomized Controlled Trial

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Purpose: Isothermic irrigation decreases the reduction in core temperature and shivering in patients undergoing transurethral resection of prostate gland but this effect has not been studied in patients undergoing endoscopic urethral stone treatment surgery. The current study is designed to study the effect of isothermic hydration on core temperature in patients scheduled for endoscopic urethral stone treatment surgery under spinal anesthesia.

Materials and Methods: Sixty patients allocated randomly into two groups. In GroupW (n = 30) irrigation fluid at 37°C was used whereas at room temperature in GroupRT (n = 30). Spinal anesthesia was performed at L3-L4 interspace with 15mg of hyperbaric bupivacaine. Core temperature, shivering, and hemodynamic parameters were measured every minute until 10th minute and five minute intervals until the end of operation. Shivering and surgeon comfort was also recorded. The primary outcome was the core temperature at the end of surgery. Frequencies, means, standard deviations, percentages, chi-square tests, independent samples t-test, and Mann Whitney *U* tests were used where eligible for the statistical analysis.

Results: Baseline core temperature was 36.6 ± 0.4°C in GroupW and 36.6 ± 0.5°C in GroupRT (*P* = .097) which decreased to 36.0 ± 0.5°C and 35.2 ± 0.7°C respectively (*P* = .018) at the end of operation. Shivering was observed in 36.7% (n = 11) in GroupRT and 6.7% (n = 2) in GroupW (*P* = .012). Hemodynamic parameter changes and demographic data were not significant between groups.

Conclusion: Isothermic irrigation decreases both the reduction in core temperature and the incidence of shivering while increasing the surgeon comfort.

Keywords: core temperature; endoscopes; isothermic irrigation, shivering, spinal anesthesia, urethral stone treatment surgery

INTRODUCTION

Endoscopic urethral stone treatment surgery is usually performed with spinal anesthesia in outpatient settings. Spinal anesthesia affects the thermoregulatory homeostasis by decreasing the vasoconstriction and shivering thresholds by 0.5°C.[1,2] Because the surgical procedure has a short duration, monitorization of the patient for hypothermia is generally neglected during endoscopic urethral stone treatment surgery. However, the duration of surgery may exceed an hour when it is a complicated case. In such a case the amount of irrigation fluid may be excessive and may accelerate the development of hypothermia.

Maintaining core temperature is an important phenomenon under spinal anesthesia. Perioperative hypothermia defined as core body temperature ≤ 36.0°C is a common inadvertent result of both general and regional anesthesia due to heat redistribution from core to periphery affected by ambient temperature,[3] duration of exposure to cold,[4] temperature of the fluid administered via intravenous route[5] or as irrigation and antimicrobial solutions used for skin preparation. Hypothermia has well documented deleterious effects[6] as increased bleeding from the surgical site,[7] reversible dysfunction of platelets,[8] shivering,[9] increased oxygen consumption and cardiac morbidity,[10] increased risk of wound infection,[11] delayed recovery from anesthesia,[12] and increased length of hospital stay.[13] Therefore perioperative hypothermia should be avoided whenever possible.

Several previous studies have defined different protocols to maintain core temperature during transurethral resection of prostate as well as arthroscopic surgeries up to date.[14-25] Main goal of these previous studies was to determine the effect of irrigation fluid temperature on core body temperature. Except for the studies reported by Oh JH et al.[20] and Jaffe et al.[16] almost all studies supported the use of warmed irrigation fluids to maintain core temperature in perioperative setting.

The effects of irrigation fluid temperature on core body temperature during transurethral resection of prostate gland was studied in previous articles but this effect was not investigated for patients scheduled for endoscopic urethral stone treatment surgery. In this prospective

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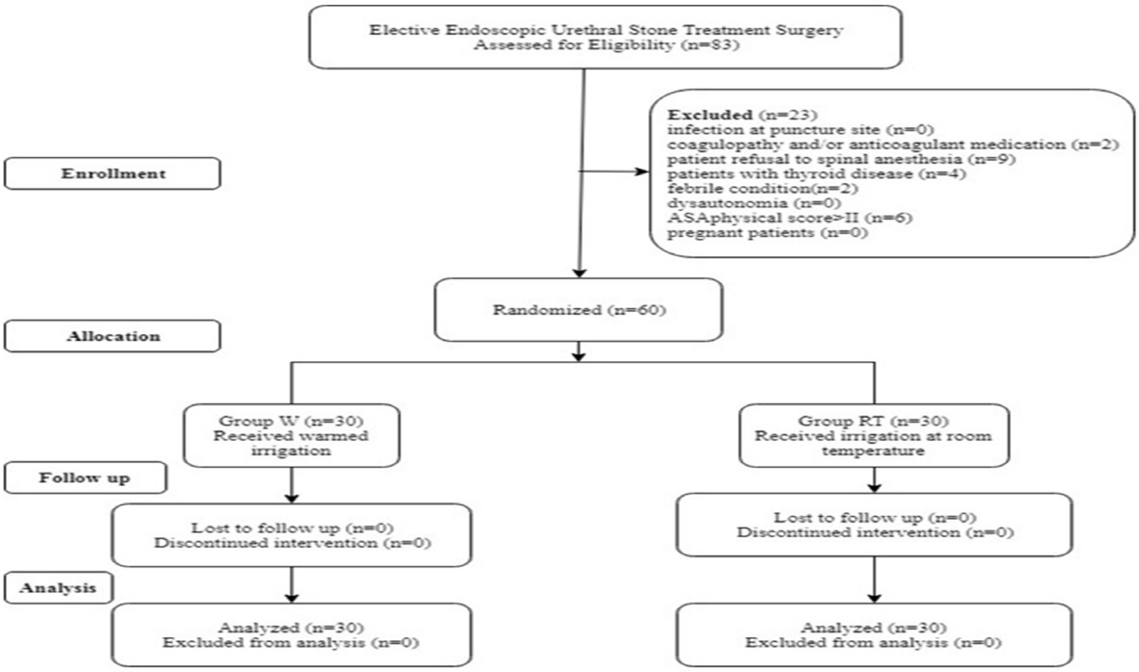

Figure 1. CONSORT Flow-diagram

randomized controlled trial we decided to investigate the effect of irrigation fluid temperature on core body temperature during endoscopic urethral stone treatment surgery under spinal anesthesia.

PATIENTS and METHODS

Ethics

This prospective, randomized controlled trial was conducted at Ahi Evran University Training and Research Hospital, Kirsehir, Turkey between August 2016 and December 2016 in line with the CONSORT statement. After receiving approval from the Ethical Committee (Turgut Özal University Clinical Trials Ethical Committee, 99950669/115, approved at 23.05.2016) the study was registered at Australian New Zealand Clinical Trials Registry (ACTRN12616000795493, registered at 17.06.2016). The study was designed and conducted in adherence to the Consolidated Standards of Reporting Trials (CONSORT) statement, Good Clinical Practice Guidelines, and Declaration of Helsinki. Written informed consent was obtained from all participants.

Study Population

Sixty patients with American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective endoscopic urethral stone treatment surgery under spinal anesthesia was included in the study (**Figure 1**). Patients that have a contraindication for spinal anesthesia (infection at puncture site, coagulopathy, anticoagulant medication or patient refusal to spinal anesthesia), patients with thyroid disease or any febrile condition, dysautonomia, ASA physical status > II, and pregnant patients were excluded from the study.

Study Design

The patients were allocated into two groups by sealed envelope technique at their preoperative visit. The envelope was brought in to the operation room with the patient and was opened by the anesthesiologist who will be in charge of the patient and the irrigation fluid temperature was adjusted according to patients' group allocation by the same anesthesiologist. The irrigation fluid and the intravenous fluids were given at room temperature in Group RT (n = 30). Group W (n = 30) received irrigation fluid at body temperature (37°C) and the intravenous fluids at room temperature. The irrigation fluid in group W was warmed by an incubator (Nuve FN500, Ankara, Turkey) set at 37°C and was protected in a non-transparent heat protection bag. The temperature of the irrigation solution was controlled with an infrared thermometer (Riester ri-thermo®N, Rudolf Riester GmbH, Germany) by the anesthesiologist in charge of the patient. The manufacturer of Riester ri-thermo®N (Rudolf Riester GmbH, Germany) states that the thermometer gives accurate measurements between 0 – 100°C and its use is appropriate for measuring body temperature, ambient temperature and fluid temperature. Ambient temperature was recorded before spinal anesthesia. All core body temperature was measured from the same tympanic membrane by the same investigator. All measurements in the study were done by an investigator other than the anesthesiologist in charge of the patient care, who was blinded for the temperature of the irrigation fluid. The thermometer used for the study was same for all the participants that had a disposable sleeve for each patient.

In the operating room, the anesthesiologist in charge of the patients monitored the patients with standard ASA monitors (electrocardiogram, pulse oximeter, non-invasive blood pressure). Baseline hemodynamic data (heart rate and non-invasive blood pressure were measured with the monitor of the anesthesia device, peripheral oxygen saturation was measured with pulse oxymeter), ambient temperature and core body temperature (both

Table 1. Demographic Data of the Patients and Surgery Variables.

[a]Characteristics		Group W (n = 30)	Group RT (n = 30)	*P*
Age(y)		44.2 ± 11.1	44.3 ± 10.7	.972
Height(cm)		168.4 ± 8.8	169.9 ± 10.2	.553
Weight(kg)		84.7 ± 12.4	83.8 ± 13.9	.810
BMI(kg/m^2)		29.4 ± 3.9	29.2 ± 5.2	.910
ASA [n(%)]	I	17 (56.7)	15 (50.0)	.796
	II	13 (43.3)	15 (50.0)	
IV Volume (mL)		930.0 ± 265.4	880.0 ± 392.1	.642
İrrigation Fluid Volume (mL)		2040.0 ± 1553.2	1866.7 ± 1568.0	.745
Duration of Surgery (min)		32.8 ± 13.8	30.4 ± 18.5	.576
Ambient temperature (°C)		23.3±1.1	23.7±1.1	.876

Abbreviations: Group W, patients received irrigation fluid at 37°C; Group RT, patients received irrigation fluid at room temperature; BMI, body mass index; ASA, American Society of Anesthesiologists; *P*, statistical significance; [a]Data are presented as mean ± SD, or number (percent).

measured with Riester ri-thermo®N) were recorded before starting intravenous infusion. A 16G intravenous line was secured on the dorsum of left hand. All intravenous fluids were given at room temperature. Temperature of the irrigation fluid was adjusted according to the group allocation of the patient by the anesthesiologist in charge of the patient. Intrathecal space was introduced with a 26G atraumatic spinal needle (Atraucan, BBraun, Melsungen, Germany) by the same anesthesiologist at L4-L5 interspace navigated by ultrasonography with 15mg 0.5% hyperbaric bupivacaine. Intrathecal local anesthetic solution was opioid free. The level of spinal anesthesia was monitored with loss of sensation to pinprick test at midclavicular line and recorded at the same time points with core temperature measurements by another anesthesiologist blinded for the temperature of the irrigation fluid. All patients were covered with a single layer of sterile surgical cover at lithotomy position.

None of the active warming modalities were used until the core temperature was below 34°C or patient had a shivering score > 3. Surgery was commenced when spinal block reached ≥ T6 dermatome determined by loss of sensation to pain with pinprick test. Core body temperature and hemodynamic data were collected every minute for the first ten minutes and with five minute intervals till 30 minutes after spinal anesthesia and at the end of surgery. Patients were transferred from operation room to post anesthesia care unit (PACU) after measurements of 30th minute follow-up data were recorded even if the surgery is completed earlier. Data for demographic variables, total duration of surgery, ambient temperature, amount of intravenous fluids and irrigation solution, spread of spinal anesthesia, amount of atropine and ephedrine used and shivering were recorded.

Table 2. In-Group and Between Groups Comparison of Temperature Change with Time

Time (min)	Group W (n=30)	Group RT (n=30)	[a]*P*
T 0 (min)	36.6 ± 0.4	36.6 ± 0.5	.977
T 1 (min)	36.6 ± 0.5	36.6 ± 0.5	.610
T 2 (min)	36.6 ± 0.5	36.5 ± 0.5	.643
T 3 (min)	36.5 ± 0.5*	36.4 ± 0.6*	.469
T 4 (min)	36.4 ± 0.6*	36.3 ± 0.5*	.379
T 5 (min)	36.4 ± 0.5*	36.3 ± 0.5*	.960
T 6 (min)	36.4 ± 0.5*	36.2 ± 0.4*	.698
T 7 (min)	36.3 ± 0.5*	36.2 ± 0.5*	.676
T 8 (min)	36.2 ± 0.5*	36.1 ± 0.4*	.811
T 9 (min)	36.1 ± 0.5*	35.9 ± 0.5*	.453
T 10 (min)	36.1 ± 0.5*	35.8 ± 0.4*	.256
T 15 (min)	36.0 ± 0.6*	35.6 ± 0.5*	.051
T 20 (min)	36.0 ± 0.6*	35.4 ± 0.5*	.038
T 25 (min)	36.0 ± 0.6*	35.1 ± 0.5*	.015
T 30 (min)	36.0 ± 0.5*	35.1 ± 0.7*	.013
T OP (min)	36.0 ± 0.5*	35.2 ± 0.7*	.018
Δt (°C)	0.6 ± 0.4	1.4 ± 0.7	.016
[b]P	.000	.000	

Abbreviations: Group W, patients received irrigation fluid at 37°C; Group RT, patients received irrigation fluid at room temperature; T, core body temperature (numbers near T indicates the time after spinal anaesthesia); □t, the difference of temperature between and baseline value and at the end of surgery

*, in-group statistically significant temperature change between actual temperature and baseline value; a, Independent Samples *t* Test (Mean ± SD); b, Repeated Measures ANOVA; *P*, statistical significance.

Shivering was graded according to the scale defined by Wrench et al.[26]: 0 = no shivering; 1 = one or more of the following: piloerection, peripheral vasoconstriction, peripheral cyanosis without other cause, but without visible muscular activity; 2 = visible muscular activity confined to one muscle group; 3 = visible muscular activity in more than one muscle group; and 4 = gross muscular activity involving the entire body. Active warming was commenced when the shivering score of the patient was > 3 for ethical reasons.

Effect of irrigation fluid temperature on surgeon comfort was assessed by a questionnaire graded between one to three which was completed by the surgeon at the end of the surgery where 1= I finished my surgery conventionally, 2 = I was not comfortable during the surgery, 3 = I was comfortable during the surgery.

The primary outcome of the current study is core body temperature at the end of surgery. The secondary outcomes were the incidence of shivering and the degree of surgeon comfort at the end of surgery. We hypothesized that isothermic irrigation will help us to maintain patients' core temperature and decrease the incidence of shivering while increasing the surgeon comfort.

Statistical Analysis

Power analysis was performed with G*Power 3.1.9.2 software. According to a previous study[22], where patients in Group I received isothermic irrigation and Group II received irrigation at room temperature. In this study, baseline body temperatures were not significantly different (*P* = .60) between groups but during surgery body temperature of the patients in Group II decreased nearly 1°C more than patients in Group I (*P* < 0.001). With a significance of .05 and a power of .86; a sample size of 30 in each group was necessary for the current study.

Table 3. Distribution of Shivering

aShivering Data		Group W(n = 30)	Group RT (n = 30)	P
Shivering [n(%)]	0	28 (93.3)	19 (63.3)	.012
	> 0	2 (6.7)	11 (36.7)	
	1	2 (6.7)	2 (6.7)	
	2	--	6 (20.0)	
	3	--	2 (6.7)	
	4	--	1 (3.3)	

Abbreviations: Group W, patients received irrigation fluid at 37°C; Group RT, patients received irrigation fluid at room temperature. *P* = statistical significance. Data are presented as numbers and frequencies. Shivering is graded between 0 and 4. aData are presented as mean ± SD, or number (percent)

Data collected from the current study was analyzed with IBM SPSS version 23.0 (SPSS Inc., Chicago, IL, USA). Frequencies, percentages, mean, and standard deviation were used to analyze descriptive data. Qualitative data was analyzed with Pearson chi square (x^2), Yates (x^2) or Fisher's (x^2) tests. Normal distribution of data was analyzed with Kolmogorov-Smirnow and Shapiro-Wilk tests. Independent Samples *t*-test, Mann Whitney-*U* test, Repeated Measures Analysis of Variance tests were used for the comparison of data between groups. LSD (post-hoc) test was used to analyze the difference between data sampling intervals. Probability (*P*) of less than .05 was accepted as statistically significant.

RESULTS

There was no statistically significant difference in patient and surgical variables as age, height, weight, BMI, ASA physical status, IV and irrigation fluid volume, duration of surgery, and ambient temperature (**Table 1**). Maximum spread of spinal anesthesia in both groups reached to T5 dermatome (*p* = .352) and all patients completed the surgery under spinal anesthesia. Need for atropine (n = 1, 3.3% in Group W; n = 4, 13.3% in Group RT) and ephedrine (n = 2, 6.7% in Group W; n = 2, 6.7% in Group RT) was not significantly different between groups (P = .353 and .617 respectively).
Baseline core body temperature was 36.6 ± 0.4°C in Group W and 36.6 ± 0.5°C in Group RT which was not statistically significant (*P* = .977). There was a gradual decrease in core temperature compared to basal core temperatures in both groups and the change in temperature was significant after the third minute until the end of surgery (*P* = .000, in-group analysis). The decrease in core temperature was statistically significant between groups after 20th minute until the end of surgery (**Table 2, Figure 2**). The change in temperature at the end of surgery was 0.6 ± 0.4°C in Group W and 1.4 ± 0.7°C in Group RT which was statistically significant (*P* = .016).
Shivering was observed in 2 patients (6.7%) in Group W and 11 patients (36.7%) in Group RT, and the difference was statistically significant (*P* = .012). We observed shivering ≥ 20 minutes after induction of spinal anesthesia in both groups. This was the time point where the change in core temperature was statistically significant between groups. Of the 11 patients in Group RT, 2 had grade 1 shivering, 6 had grade 2 shivering, 2 had grade 3 shivering and 1 had grade 4 shivering and this patient was warmed with active warming. However, the two patients that shivered in group W had grade 1 shivering (**Table 3, Figure 3**).
There was a statistically significant difference in surgeon comfort between groups (*P* = .000). In group W surgeons stated they were comfortable in 29 cases but in Group RT they were only comfortable in 11 cases (**Table 4**). No complications were reported during the operation and within the postoperative 24 hours.

DISCUSSION

Our study has shown that use of isothermic irrigation in endoscopic urethral stone treatment surgery with spinal anesthesia is effective to decrease the incidence of intraoperative hypothermia and one of its perturbing results shivering as well as increasing surgeon comfort. Hypothermia under spinal anesthesia is a common occurrence but it is not considered by most of the anesthesiologists[27] especially when the predicted duration of operation is short. Hypothermia under spinal anesthesia is affected by the ambient temperature,[3] the magnitude and duration of surgery,[4] and the temperature of intravenous fluids given.[5] Endoscopic urethral stone treatment surgery is a short lasting surgical procedure, when uncomplicated, and carried out in outpatient settings in our institution. Up to date we were not monitoring this patient group for hypothermia as most of the anesthesiologists do worldwide. However the results of the current study have shown that there is a significant core temperature difference between basal values and the temperature measured at the end of operation if the patients are irrigated with fluids at room temperature rather than irrigated with isothermic fluids. In our study, the difference in core body temperature in isothermic irrigation group was 0.6 ± 0.4°C and 1.4 ± 0.7°C in patients receiving irrigation fluid at room temperature (*P* = .016). The amount of irrigation fluid, intravenous

Table 4. Surgeon Comfort Distribution.

aSurgeon Comfort		Group W (n = 30)	Group RT (n = 30)	P
Surgeon Comfort		3.0 ± 0.2	2.2 ± 0.7	.000
	1	0 (0.0%)	5 (16.7%)	.000
	2	1 (3.3%)	14 (46.7%)	
	3	29 (96.7%)	11 (36.7%)	

Abbreviations: Group W, patients received irrigation fluid at 37°C; Group RT, patients received irrigation fluid at room temperature; Data is presented as means ± standard deviations and percentages. *P* = statistical significance. aData are presented as mean ± SD, or number (percent)

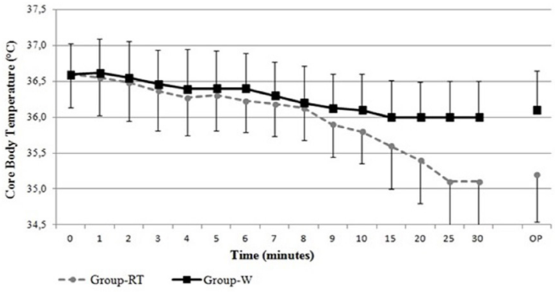

Figure 2. Temperature Changes in Groups with Respect to Time

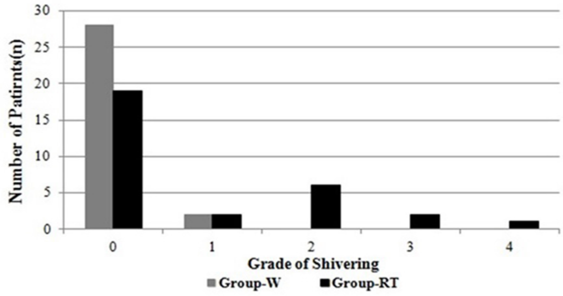

Figure 3. Distribution of Shivering According to Grade

fluid, the duration of surgery and ambient temperature were not significantly different between the groups in the current study ($P > 0.05$). The temperature of the irrigation fluid was the only different variable effecting the change in core temperature. Our study results were in accordance with most of the previous studies performed to analyze the effect of irrigation fluid temperature on core body temperature[14,18,21-24] but Jaffe et al. [16] have documented that length of stay in operation room, ambient temperature, and the amount of absorbed irrigation fluid might have a greater effect on core body temperature than the irrigation fluid temperature in patients undergoing transurethral resection of the prostate gland. However, in the current study the only parameter affecting the core body temperature at the end of operation was the temperature of the irrigation fluid and we found a significant difference between the groups. In our study, ambient temperature and length of stay in operating room were not significantly different between groups. Unlike transurethral resection of prostate gland, there is not much fluid absorption in endoscopic urethral stone treatment surgery which is speculated to affect the change in core body temperature by Jaffe et al.[16] We did not use active warming modalities until the core body temperature of the patient was below 34°C whereas Jaffe et al.[16] used external warming for their patients which may have affected their results.

In the current study the incidence of decrease in core body temperature was less with isothermic irrigation but could not be prevented in all participant patients. Besides isothermic irrigation, active warming devices and warmed intravenous fluids should be used to prevent hypothermia when eligible to avoid well known perturbing effects of hypothermia. But we have to acknowledge the clinicians to strictly control the warmed irrigation fluid temperature to prevent thermal injury to the bladder and the urinary tract. Okeke[21] have reported that although patients receiving isothermic irrigation and intravenous hydration at room temperature in their Group2, some decrease in core temperature still occurred as in our study but when warmed intravenous and isothermic irrigation fluids were given no alterations in core body temperatures were observed.

There are four reliable sites defined to measure core body temperature: pulmonary artery, nasopharynx, distal esophagus, and tympanic membrane.[2] The first three measurement sites are inappropriate to monitor core temperature in an awake patient under spinal anesthesia. Therefore we used tympanic membrane temperatures measured with infrared tympanic thermometer (Riester ri-thermo®N, Rudolf Riester GmbH, Germany) which by its manufacturers is said to give accurate measurements between 0-100°C.

In our study shivering was graded according to scale defined by Wrench et al.[26] Patients who had shivering started to shiver ≥ 20 minutes after administration of spinal anesthesia which was consistent with the observation of statistically significant difference in core body temperature between groups. Shivering was observed in two patients (6.7%) in Group W and eleven patients in Group RT (36.7%). These results are in accordance with the results of Okeke et al.[21] where in their study 13 of 40 patients in Group1 and 3 of 40 patients in Group2 had shivering.

Surgeon comfort during endoscopic urethral stone surgery is inversely proportional to the presence and degree of shivering. When patient starts to shiver, it becomes very difficult for the surgeon to manipulate the lithotripter (Sphinx 30 litho, LISA laser products OHG, Katlenburg-Lindau, Germany) therefore the surgeon asks the anesthesiologist in charge of the patient for decreasing the degree of shivering or preventing it. The results of surgeon comfort in the current study was significantly higher in Group W ($P < .001$) compared to Group RT. Besides improvement in surgeon comfort with warmed irrigation during endoscopic surgeries, Mohammadzadeh Razaei et al.[28] have reported that they obtained better surgical outcomes when warmed irrigation is used hovewer in an editorial and the response letter to this editorial it was reported that these results needed validation with more studies with higher sample size.[28,29]

Limitations of our study includes the data collection time was limited with thirty minutes. Although measurement of core temperature continued while patients were in PACU, these measurement results were not collected as study data according to study protocol. Patients were warmed with active warming modalities if their core temperature was below 340C or shivering score was > 3 at PACU. The patients were hydrated with fluids at room temperature but it is recommended to infuse IV fluids at 37°C. Another limitation of the study was patient comfort was not included in the study protocol.

CONCLUSIONS

In conclusion, isothermic irrigation during endoscopic urethral stone treatment surgery decreases the incidence of postoperative hypothermia and shivering while increasing surgeon comfort. Although the surgical procedure lasts shorter and the amount of irrigation fluid is less compared to transurethral resection of prostate gland, isothermic irrigation provides similar benefits against intraoperative hypothermia and its perturbing comorbidities during endoscopic urethral stone treatment surgery under spinal anesthesia.

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None to declare.

CONFLICT of INTEREST

The authors declare no conflict of interest.

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