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Original Article

Effect of Irrigation Fluid Temperature on Hypothermia and Complications in TURP Patients Under Spinal Anesthesia: A Randomized Clinical Trial

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Abstract

Background: Hypothermia during surgical procedures increases the risk of complications. This study aimed to compare the effects of Irrigation Fluid (IF) temperature on hypothermia, hemodynamic changes, and complications in patients undergoing Transurethral Resection of the Prostate (TURP) surgery under Spinal Anesthesia (SA).

Methods: In this double-blind clinical trial, 76 patients scheduled for TURP surgery were randomly assigned to two groups. The first group received warm IF heated to 37°*C*, while the second group received IF at room temperature. Body temperature and hemodynamic parameters were measured at five time points: upon entering the operating room (T0), after spinal anesthesia (T1), at the start of surgery (T2), at the end of surgery (T3), and during recovery (T4).

Results: In evaluating the trend of core mean body temperature changes, there was a statistically significant difference over the study period (T0-T4) in each group ($p<0.001$). A significant difference in mean body temperature between the two groups was observed at T2 and T3 ($p<0.05$), indicating higher body temperatures in group one. Additionally, there was a statistically significant difference between the two groups in terms of shivering, the need for pethidine injection, and blood product transfusion. However, no statistically significant difference was found between the groups in terms of the trends of changes in hemodynamic parameters over the study period (T0-T4).

Conclusion: Using IF heated to body temperature was associated with a lower incidence of hypothermia, reduced shivering, and fewer blood transfusions compared to room temperature IF during TURP surgery.

Keywords: Hypothermia, Irrigation fluid, Spinal anesthesia, Transurethral resection of prostate (TURP)

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Introduction

Benign Prostatic Hyperplasia (BPH) is a common disease in elderly patients that causes annoying symptoms in the lower urinary tract. Transurethral Resection of the Prostate (TURP) is one of the surgical methods for treating this disease, requiring constant bladder irrigation to prevent blood clots and catheter-related infections (1-3). The low temperature of the Irrigation Fluid (IF) can lead to hypothermia, bleeding, and shivering. These consequences not only have adverse effects on the outcome of the operation but also increase the length of hospital stay. Perioperative hypothermia refers to an unintentional decrease in core body temperature below 36 degrees Celsius either during or immediately after a surgical procedure (3,4). Hypothermia, as an unpleasant perioperative complication, can result in harmful effects such as cardiac arrhythmia, ischemia, and impaired drug metabolism. It can also prolong recovery time, alter mental status, and lead to renal dysfunction, bleeding, delayed wound healing, and an increased risk of infection. Furthermore, hypothermia increases oxygen consumption, disrupts peripheral circulation, and contributes to hypercarbia and hypoxia (3-7).

The difference in perioperative body temperature is influenced by factors such as the functioning of the temperature regulation system in different patients and the type and duration of the operation, especially in procedures with extended bladder irrigation times (3-5). Patients undergoing TURP are often elderly, which is a significant independent risk factor for hypothermia. This factor increases complications both during and after the operation while delaying the patients' recovery (3,8,9). Moreover, Spinal Anesthesia (SA) is often preferred for these patients due to its ease of administration, appropriate dosage requirements, and its suitability for elderly patients with heart or lung conditions. However, SA itself disrupts the autonomic system's thermoregulatory function, leading to heat loss (3). Since core body temperature is not typically monitored during regional anesthesia, significant hypothermia often goes undetected (3). Despite body temperature being a vital sign, hypothermia during TURP is often given relatively little attention by urologists (8). Although some studies have shown that the use of warmed IF is effective in reducing both heat loss and the hemodynamic response (3-10), the optimal temperature of the IF for TURP remains unknown, thus the debate over the effectiveness of treatments to prevent hypothermia and shivering continues. Given the significant complications that occur during and after surgery, along with the high costs associated with treating these complications, the aim of this study was to compare the effects of different IF temperatures on body temperature, hemodynamics, and complications in two groups of patients undergoing TURP surgery under SA.

Materials and Methods

Study type and population

In this prospective double-blind randomized clinical trial, patients who were candidates for TURP surgery from July 2019 to May 2020 at Razi Hospital were randomly divided into two groups using block randomization. After the approval of the Ethics Committee of Guilin University of Medical Sciences (Identifier: IR.GUMS.REC.1399.322), it was registered in the Iranian Registry of Clinical Trial (IRCT) (Identifier: IRCT20121216011766N6; https://www.irct.ir). The inclusion criteria included all the candidates for elective TURP surgery with ASA class II-III and age between 40-75 and a body mass index of less than 30 kg/m^2 with an operation duration of less than two hours. Exclusion criteria included active infection, consumption of antipyretic drug within 24 *hr* before the operation, neuropathy, thyroid dysfunction or thyroid hormone use, peripheral vascular disease, spinal contraindications, history of taking ACEI or calcium channel blockers, history of bleeding diseases, and history of taking anticoagulant drugs.

Also, patients with an operation duration of less than one hour or more than two hours, severe bleeding before or during surgery, the occurrence of complications requiring the opening of the abdomen, and the occurrence of shock and unstable hemodynamics were excluded from the study. According to Singh *et al*'s study (3), the sample size was determined, which reported a substantial effect size of 0.8 for the body temperature difference. With a 95% confidence interval, 80% power, and a 10% attrition rate, a total of 38 subjects were calculated for

each group. The required sample was purposefully selected according to the eligibility criteria. The participants were randomized into groups using the random block method with a sequence that was generated using sealedenvelope.com.

Study outcomes

The primary outcome of the study was body temperature that was measured at five-time points at entering the operating room (T0), after the SA (T1), at the beginning of the surgery (T2), at the end of the surgery (T3), and also during the recovery (T4). The secondary outcomes were hemodynamic variations, incidence of shivering, intensity of shivering, recovery time, and the volume of fluids and blood products received during the surgery

Procedures

The day before surgery, the patients were visited by the anesthesiologist responsible for the visit plan. The anesthesia technique, along with its advantages, disadvantages, evaluation methods, and necessary explanations, was discussed with the patients. Written informed consent was obtained, and the patients were then randomly divided into two groups. In the first group, the IF was heated to body temperature (37°*C*) using an incubator device (Sazgarmed steamer, Iran, with a capacity of nine serums, 35×30×30 *cm*). In the second group, the IF was at room temperature (21-23°*C*). Warming of the IF was done by an anesthetist, separate from the study investigators, due to the randomized, double-blind nature of the study. The warmed fluids' temperature was rechecked before use and reheated if necessary.

Data collection before, during, and after surgery was performed by one of the researchers, who had no role in patient anesthesia and was thus blinded to the patient's group. Upon entering the operating room, all patients were subjected to standard monitoring, including a 3-lead electrocardiogram (ECG), non-invasive blood pressure (NIBP), pulse oximetry (Saadat digital monitoring, Tehran, Iran), and body temperature measurement using an infrared ear thermometer (Allianced Manufacture, E-Care Technology Co., Taiwan). Baseline body temperature, heart rate, blood pressure, and oxygen saturation were recorded. Body temperature was measured at five time points: upon arrival in the operating room (T0), after spinal anesthesia (T1), at the start of surgery (T2), at the end of surgery (T3), and during recovery (T4). After inserting an 18-gauge intravenous line, 5 *ml/kg* of normal saline at room temperature was administered over 15 to 30 *min*. The patient was then placed in a sitting position, and 12.5 *mg* of 0.5% hyperbaric bupivacaine was injected at the L3-L4 or L4-L5 vertebrae using a 25-gauge needle (B Braun company, Germany).

After the block was administered, the patient was placed in the supine position, and the level of the block was checked using the pinprick method. Surgery began when the block level reached T10. The temperature in the operating and recovery rooms was maintained between 21-23°*C*, as measured by a wall-mounted thermometer at the patient level. The patients were covered with three layers of fabric during surgery, and none of the patients were actively heated during or after the procedure. Hemodynamic parameters, including Mean Arterial Pressure (MAP) and Heart Rate (HR), were recorded every five *min*s throughout the operation. In cases of hypotension (a drop of more than 20% from baseline), 5 *mg* of ephedrine (up to a maximum of 30 *mg*) was administered. For bradycardia (HR less than 50 beats per *min*), 0.5 *mg* of atropine was injected intravenously. During the recovery, the patients were covered with a blanket and received oxygen via face mask at 6 *L/min*. In cases of shivering, 25 *mg* of intravenous pethidine was administered. The incidence and intensity of shivering, recovery time, and volume of fluids received during surgery were recorded for each patient. Due to the large volume of irrigation fluid used during this type of surgery, which mixes with the patients' blood, it was not possible to accurately measure the intraoperative blood loss.

Instead, bleeding was estimated by measuring hemoglobin levels before and after surgery and comparing the drop in hemoglobin, as well as the number of blood units transfused during the procedure. All the patient information was collected using data collection forms, files, and interviews.

Statistical analysis

Data were analyzed using descriptive statistics, including mean and standard deviation (SD).

Normality assumptions were assessed with the Kolmogorov-Smirnov test. Between-group differences were evaluated using repeated measures Analysis of Variance (RMANOVA), adjusting for baseline values as covariates. Additionally, between-group differences were analyzed using T-tests. Marginal mean scores with 95% Confidence Intervals (CI) were estimated using RMANOVA. Statistical analyses were conducted using SPSS version 25. The p-values less than 0.05 were assumed statistically significant.

Results

A total of 93 patients underwent TURP surgery during the study period. Of these, 6 patients did not meet the inclusion criteria, and 7 patients refused to participate in the study. The remaining patients were divided into two groups: one group receiving warm IF (group one) and the other receiving room temperature IF (group two). Two patients in group one and one patient in group two were excluded from the study due to prolonged operation times and the need for general anesthesia. Additionally, in group two, one patient was excluded due to complications requiring abdominal surgery. Ultimately, 38 patients in group one and 38 patients in group two were included in the study (Figure 1). The average age of the patients in groups one and two was 67.92±7.75 and 67.13±10.50, respectively, with no statistically significant difference between the two groups (p=0.657). The majority of patients in both groups were in the 61-70 age range, while the fewest patients were in the under 60 age group. In assessing the trend of changes in the mean body temperature of the patients in groups one and two, there was a statistically significant within-group difference from T0 to T4 ($p<0.001$) in both groups. Additionally, a statistically significant between-group difference in body temperature was observed at T2 and T3 ($p<0.05$). Specifically, the mean body temperature in group one decreased from 36.18±0.56 at T0 to 36.07±0.62 at T2, while in group two, it decreased from 36.03±0.52 at T0 to 35.54±0.39 at T2, indicating a greater decrease in body temperature in group two (Table 1, Figure 2).

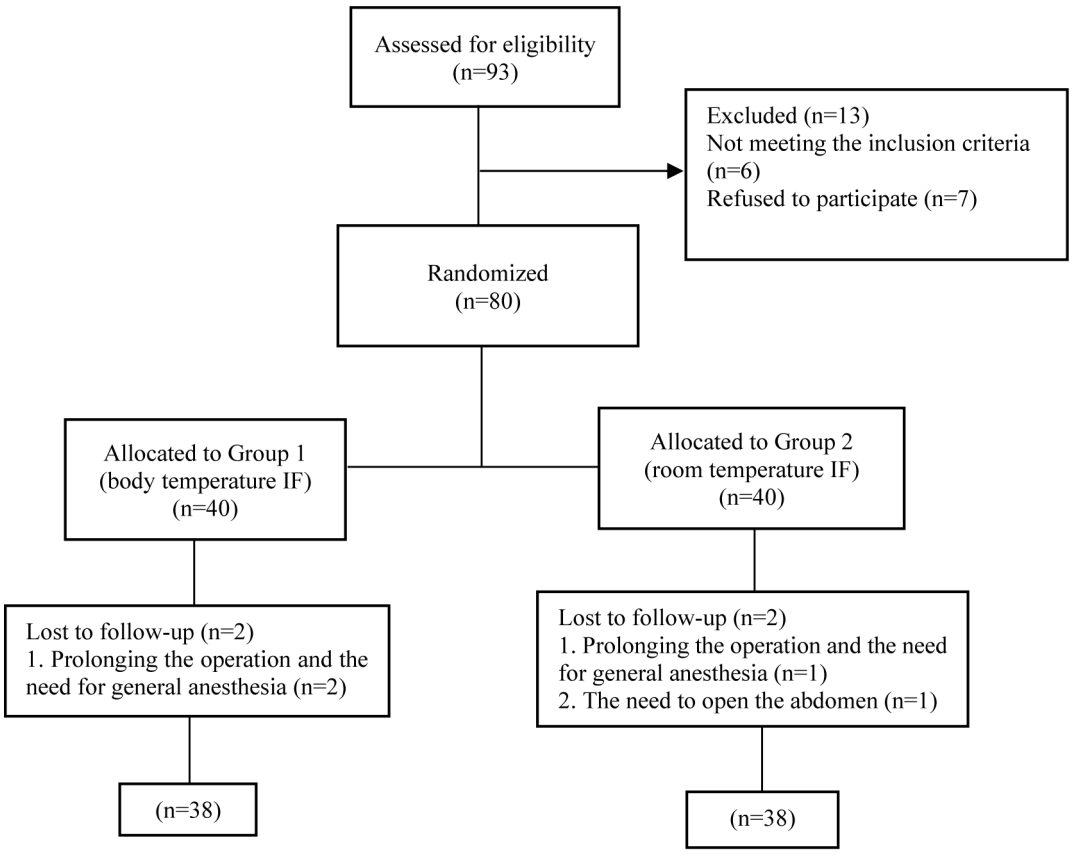

Figure 1. Consort form of the study.

Table 1. Comparison of the average body temperature (degrees Celsius), MAP and heart rate of TURP candidate patients

Variable/ Time	Body temperature			MAP			Heart rate		
	Group 1 body temp	Group 2 room temp	Between group p-value	Group 1 body temp	Group 2 room temp	Between group p-value	Group 1 body temp	Group 2 room temp	Between group p-value
T0	36.18±0.56	36.03±0.52	0.219*	105.92±12.8	107.96±17.42	0.562*	76.47±13.53	77.89±12.72	0.639*
T1	36.14±0.57	35.92±0.51	0.081*	100.96±12.07	101.05±15.92	0.978*	73.81±12.48	74.31±10.55	0.851*
T2	36.07±0.62	35.54±0.39	<0.001*	100.18±9.52	99.86±11.9	0.897*	70.34±12.68	72.31±13.32	0.51*
T3	35.91±0.60	35.58±0.42	0.008*	98.85±10.59	98±13.35	0.759*	66.23±11.16	68.34±10.42	0.398*
T4	36.01±0.56	35.79±0.5	0.076*	97.61±9.99	98.25±13.33	0.813*	66.36±11.06	68.36±10.52	0.422*
Within group p-value	p<0.0001**	p<0.0001**	-	p<0.001**	p<0.0001**	-	p<0.0001**	p<0.0001**	-
Between group marginal means p-value		0.027**			0.785**			0.88**	

*t-test (p<0.05). **Repeated Measurement ANOVA.

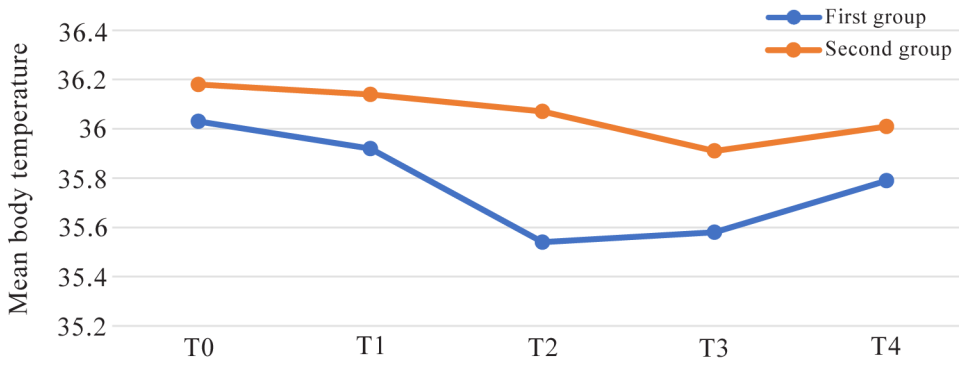

Figure 2. Changes in mean body temperature in patients of two groups.

In examining the changes in mean HR, a statistically significant difference was found within both groups over the research period (p<0.001). However, there was no statistically significant difference in HR between the two groups (p=0.83) (Figure 3). Similarly, the analysis of changes in mean MAP indicated a statistically significant difference within both groups during the research period (p<0.001), but no statistically significant difference between the two groups (p=0.85) (Figure 4). There was no statistically significant difference between the groups in the average volume of irrigation fluid used during surgery, the comparison of hemoglobin levels before and after surgery, the duration of recovery time, or the length of hospitalization. However, there was a statistically significant difference between the two groups in terms of the need for blood transfusion, the number of blood units used during surgery, the incidence of shivering, and the need for pethidine injections (Tables 2 and 3).

Discussion

This study demonstrated that using IF heated to body temperature for bladder irrigation during TURP surgery is associated with a reduced incidence of hypothermia, shivering, and the need for blood transfusion. During surgery, patients' body temperature decrease due to a combination of factors

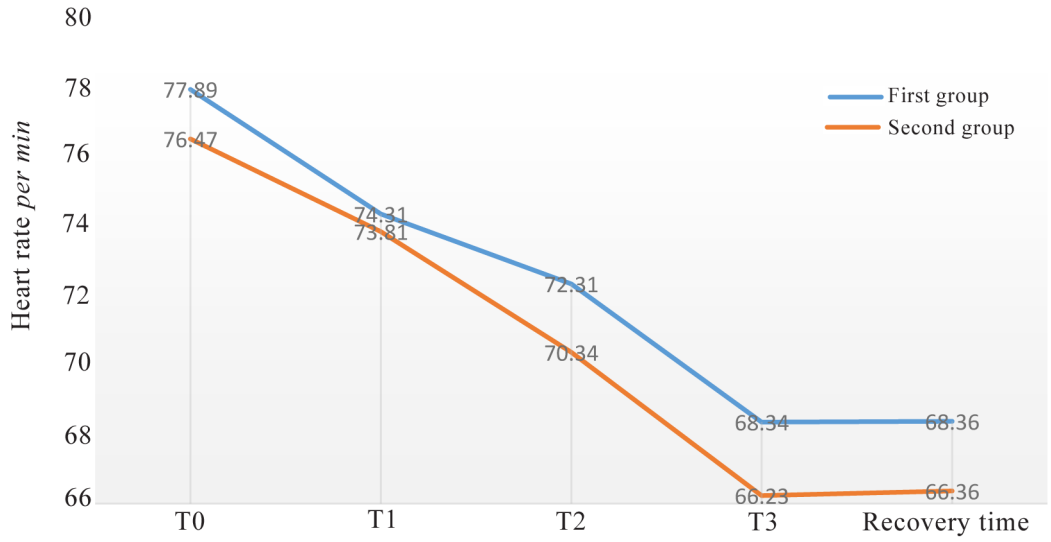

Figure 3. Changes in mean heart rate in patients of two groups.

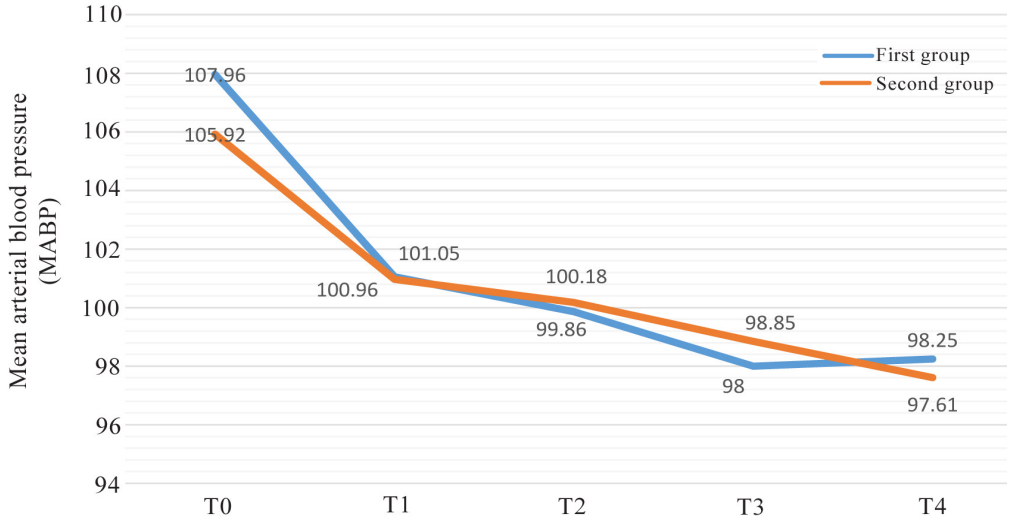

Figure 4. Changes in mean arterial blood pressure in patients of two groups.

**Repeated Measurement test (p<0.01).

Table 2. Comparison of perioperative parameters in patients of two groups

Variable	Group 1 body temp	Group 2 room temp	p-value
The volume of irrigation serum (*ml*), mean (SD)	20315.78 (SD=6199.8)	21263.15(SD=7365.6)	0.546
Preoperative hemoglobin (*dL/mg*), mean (SD)	12.06 (SD=1.62)	11.75±1.87	0.449
Postoperative hemoglobin (*dL/mg*), mean (SD)	11.26 (SD=1.54)	11±1.98	0.513
need for blood transfusion (person)	0	6(15.8)	**0.025** ■
The number of blood bags injected	0	0.15±0.36	**0.011****
Need for pethidine injection (person)	7(18.4)	16(42.1)	**0.025** ■
Injectad pethidine (*mg*), mean (SD)	5.26(SD=12.24)	11.84±14.86	0.025**
Recovery time (*min*), mean (SD)	38.68(SD=9.34)	37.36±6.75	0.484
Hospitalization period (days), mean (SD)	4.21(SD=1.06)	4.1±1.06	0.660

*t-test (p<0.05), **Mann Whitney U test (p<0.05), ■ Chi_Square test (p<0.05).

Table 3. Distribution of the frequency of shivering severity in patients of the two groups

Variable	Group 1 body temp	Group 2 room temp	p-value
Shivering			
yes	7(18.4)	16(42.1)	0.045*
no	31(81.6)	22(57.9)	
Shivering intensity			
no	31(81.6)	22(57.9)	
I	5(13.2)	9(23.7)	
II	2(5.3)	6(15.8)	0.11*
III	0(0)	1(2.6)	
IV	0(0)	0(0)	

* Chi-Square test (p<0.05).

such as anesthetic drugs, operating room temperature, insufficient covering, intravenous administration of cold solutions, and the type and duration of the surgery. IF at room temperature can lower both central and peripheral body temperatures, potentially leading to perioperative hypothermia (7,10). This hypothermia can result in a series of complications (10). Shivering, a significant side effect, increases discomfort, anxiety, and oxygen consumption, and can even lead to cardiovascular events, myocardial ischemia, and renal dysfunction (3).

TURP is a common urological procedure and the gold standard for treating patients with BPH (1). During the surgery, fluid irrigation is necessary to remove cauterized prostate tissue and enhance surgical visibility. Due to the large volume of IF required, the risk of temperature changes in patients is high (2). In examining the effects of using warmed IF on changes in body temperature during surgery, the current study found that the mean body temperature of the patients in each group gradually decreased throughout the operation. There was a statistically significant difference in the mean body temperature between the periods for each group. Additionally, the largest difference in average body temperature from the beginning to the end of the surgery was observed in the patients in Group 2. This finding indicates that the average body temperature of the group receiving room temperature IF decreased more than that of the group receiving warmed IF. In a study conducted by Singh *et al*, to investigate the effect of irrigation temperature on core body temperature and hemodynamic changes during TURP surgery, it was shown that the use of both room temperature and warm IF reduced core body temperature; however, using warm IF reduces the incidence of hypothermia and shivering (3). Also, Okeke *et al* stated that the patients who received isotherm IF had significantly fewer changes than those who received IF at room temperature (9), and the results of these studies are similar to the present study.

A survey conducted by Jaffe *et al*, aimed at exploring the impact of IF temperature on body temperature during TURP, concluded that there was no statistically significant difference in patients' body temperature before and after surgery. Moreover, they found that the temperature of the IF utilized during the procedure did not contribute to changes in body temperature (11). Factors that may affect the difference in the incidence of hypothermia between Singh's study (3) and this study with Jaffe's study (9) could be different age groups and differences in the temperature of the IF in addition to not actively rewarming the patient and using intravenous serum at room temperature. Both groups experienced decreases in hemodynamic parameters, including mean HR and MAP. Although the average of these parameters in each of the two groups had a statistically significant difference from each other during different periods, there was no statistically significant difference between the two groups. In a study by Canturk *et al* exploring the impact of utilizing isothermic fluid during endoscopic ureteral stone surgery under SA, no statistically significant differences were observed in terms of hemodynamic parameters, including mean heart rate, blood pressure, and peripheral blood oxygen saturation percentage between the two groups (12). Also, in the study of Singh *et al*, there was no statistically significant difference between the groups in terms of hemodynamic parameters, including heart rate, systolic blood pressure, and diastolic blood pressure, and the trend of changes in these parameters was decreased in both groups (3).

The reason for this pressure reduction process in the current study, similar to other studies, can be due to the effect of spinal anesthesia on the sympathetic block. In none of the patients in the study, severe and significant drops in blood pressure and heart rate

occurred, which can be attributed to receiving 5 *ml/kg* of body weight serum before anesthesia.

In the comparison of the amount of intraoperative bleeding between the two groups, it was found that there was a significant difference between the groups in terms of the amount of packed cells received during the operation. Regarding the average hemoglobin value before and after the operation, although there was a statistically significant difference in each group, comparing the two groups together, the difference between the average before and after the operation was not significant. Studies have shown that if the IF temperature induces hypothermia in the patient, not only does the likelihood of bleeding complications during the operation increase, but the patient may also require a blood transfusion.

This is caused by systemic coagulopathy, such as platelet dysfunction following a drop in body temperature (13). According to the present study, the need for blood transfusion was more in the second group than in the first group. So that 6 patients in the second group needed blood transfusion. While in group one, blood transfusion was not done in any person. So there was a significant difference between the two groups ($p<0.05$). This indicates more bleeding in patients receiving IF at room temperature than patients receiving warm IF. In addition, shivering may aggravate the pain and simply prevent wound closure by pulling the surgical incisions (4,14). In this study, the decrease in the mean core body temperature was significantly greater in patients who underwent prostate resection with room temperature IF and intravenous fluid.

Regarding the need for pethidine injections due to shivering, there was a statistically significant difference between the two groups. In the room temperature IF group, 16 patients (42.1%) required pethidine injections, compared to only 7 patients (18.4%) in the warmed IF group ($p=0.025$). Additionally, the average dose of pethidine administered was significantly higher in the room temperature IF group (11.84±14.86 *mg*) than in the warmed IF group (5.26±12.24 *mg*) ($p=0.025$). These findings are consistent with previous studies that reported significant hypothermia in patients who received room temperature IF during TURP (3,9).

Limitations

In this study, room temperature intravenous serum was used for patients in two groups, but fluid heating devices and other external measures were not used to limit heat loss in patients. Therefore, evaluating the effect of intravenous fluid temperature and active heating on changes in body temperature and other parameters was impossible. On the other hand, the sample size of this study was small. Therefore, to achieve more accurate results, studies with larger sample sizes and investigations of the effect of active heating on temperature change are recommended. Also, two variables, patient comfort and surgeon comfort, can be investigated during TURP surgery through existing questionnaires with IF at room temperature and 37 degrees. It is also recommended that a similar study be conducted comparing two types of anesthesia, general anesthesia with SA, and simultaneously investigating the relationship between the type of anesthesia and the IF temperature in the occurrence of changes in the patient's body temperature.

Conclusion

This study demonstrated that irrigating the bladder with warmed IF during TURP surgery significantly reduced the incidence of hypothermia, shivering, and the need for blood transfusions compared to using room temperature IF. Specifically, patients in the warmed IF group showed a smaller drop in body temperature at T2 ($p<0.001$) and T3 ($p=0.008$) compared to those receiving room temperature IF. Additionally, 42.1% of the patients in the room temperature IF group experienced shivering, compared to only 18.4% in the warmed IF group ($p=0.045$), which led to a significantly higher use of pethidine in the room temperature group ($p=0.025$). The reduction in the need for blood transfusions in the warmed IF group (0% *vs*. 15.8%, $p=0.025$) supports the hypothesis that maintaining normothermia reduces perioperative bleeding. Thus, warmed IF could be considered an effective and cost-efficient method to enhance patient outcomes in TURP surgeries, particularly in preventing hypothermia-induced complications.

Availability of data and materials

The datasets generated and/or analyzed in the current

study are not publicly available due to patient privacy protection but are available from the corresponding author at a reasonable request.

Ethics approval and consent to participate

The study was performed in accordance with the declaration of Helsinki and approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1399.322). It was registered in the Iranian Registry of Clinical Trial (IRCT) (Identifier: IRCT20121216011766N6; https://www.irct.ir)

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Conflict of Interest

The authors declare that they have no conflict of interest concerning this study.

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