Effect of Preoperative Forced-Air Warming on Hypothermia in Elderly Patients Undergoing Transurethral Resection of the Prostate

Youn Yi Jo, Young Jin Chang, Yong Beom Kim, Sehwan Lee, Hyun Jeong Kwak*

Purpose: Elderly patients under spinal anesthesia are vulnerable to hypothermia, leading to increased morbidity. The aim of this study was to investigate the effects of preoperative forced-air warming on perioperative hypothermia and shivering in elderly patients undergoing transurethral resection of the prostate (TURP) under spinal anesthesia.

Materials and Methods: Patients (> 65-year-old) scheduled for TURP under spinal anesthesia were randomly assigned to receive preoperative forced-air skin warming for 20 min (the pre-warmed group, n = 25) or not (control group, n = 25). Core temperatures were measured at 15-min intervals after spinal anesthesia, and intra- and post-operative shivering were also assessed.

Results: Incidences of intraoperative hypothermia (< 36ºC) in the pre-warmed and control groups were not significantly different (10/25 [40%] vs. 15/24 [62.5%], *P* = .259). However, severities of hypothermia were significantly different (*P* = .019). No patient in the pre-warmed group showed moderate or profound hypothermia, whereas of patients in control group 21% and 13% did so, respectively.

Conclusion: This study demonstrated that a brief period of preoperative forced-air warming did not completely prevent intraoperative hypothermia or shivering, but it could significantly reduce its severity in elderly male patients under spinal anesthesia.

Keywords: anesthesia; spinal; body temperature; hypothermia; etiology; prevention & control; transurethral resection of prostate; adverse effects.

INTRODUCTION

Spinal anesthesia significantly impairs thermoregulation by inhibiting vasomotor and shivering responses[1] and the redistribution of body heat,[2] and predisposes patients to perioperative hypothermia. Because elderly patients have a reduced shivering threshold,[3] they are at greatest risk of hypothermia,[4] which can lead to serious clinical complications such as, myocardial ischemia,[5] blood loss,[6] and surgical wound infection.[7] Thus, it is important to monitor and control body temperature and prevent hypothermia in elderly patients under spinal anesthesia. In addition, shivering is a major problem for surgeons during transurethral resection of the prostate (TURP). Shivering may interfere with visual field for resectable prostate tissue and increase the risk of injury to the urethra, bladder, and rectum during the surgery.

Hypothermia frequently occurs during TURP, because cold bladder irrigation fluid is an important source of heat loss and decreases core body temperature by 1-2°C.[8] In a previous study, isothermic irrigation fluid was found to significantly reduce body temperature more so than room temperature irrigation fluid.[9] However, it can difficult to warm a large volume of irrigation fluid. On the other hand, preoperative skin surface warming using a forced-air warmer for 2 h has been reported to reduce the temperature differential between the core and periphery and heat redistribution during epidural anesthesia in healthy young volunteers not undergoing surgery,[10] and in another study, pre-operative warming for 10 or 20 min reduced shivering and largely prevented hypothermia during general anesthesia in healthy adult patients.[11] A recent meta-analysis also showed that prewarming patients with forced-air warmer could effectively reduce the peri-operative hypothermia.[12] We hypothesized that preoperative surface warming using a forced-air warmer before spinal anesthesia might reduce perioperative hypothermia and shivering in elderly patients. Thus, the aim of this prospective study was to investigate the effects of preoperative forced-air warming on perioperative hypothermia and shivering in elderly male patients undergoing TURP under spinal anesthesia.

MATERIALS AND METHODS

Study Population

After obtaining approval by the institutional review board of Gachon University Gil Medical Center, written informed consent was obtained from all enrolled patients. Fifty male patients aged over 65 years of Ameri-

Department of Anesthesiology and Pain Medicine, Gachon University, Gil Medical Center, Incheon, South Korea.
*Correspondence: Department of Anesthesiology and Pain Medicine, Gachon University, Gil Medical Center,
1198 Guwol-dong, Namdong-gu, Incheon 405-760, South Korea.
Tel: +82 32 4603637. Fax: +82 32 4696319. E-mail: hyun615@gilhospital.com.
Received March 2015 & Accepted September 2015

Table 1. Demographics and perioperative data of study subjects.

Variables	Pre-warmed (n = 25)	Control (n = 24)	*P* Value
Age (years)	73 ± 6	72 ± 4	.461
Weight (kg)	63 ± 8	65 ± 6	.464
Height (cm)	165 ± 5	167 ± 4	.282
Sensory block level	T8 (T6-T10)	T8 (T6-T9)	.185
Operation time (min)	63 ± 22	55 ± 24	.360
Total irrigation fluid (mL)	8000 (3000-13500)	8000 (3000-10000)	1.00
Total infused fluid (mL)	400 (375-425)	400 (300-500)	.335

Data are expressed as mean ± SD or medians (interquartile ranges).

can Society of Anesthesiologists physical status I-II and scheduled to undergo elective TURP were enrolled in this prospective randomized study. The exclusion criteria were a pre-anesthetic tympanic membrane temperature of > 37.5ºC or < 36ºC, uncontrolled hypertension or diabetes mellitus, and a condition requiring fluid restriction, such as, end-stage renal disease, peripheral vascular disease, uncompensated heart failure, or progressive respiratory disease. Patients were not pre-medicated.

Procedure

On arrival at the pre-anesthetic care unit, standard monitors were applied and tympanic temperature was measured using an infrared tympanic thermometer (ThermoScan IRT 1020; Braun, Germany). All patients were placed under a forced-air cover and pre-warming was performed using a forced-air warmer (WarmTouch; Mallinckrodt Medical, St Louis, MO, USA). Patients were randomized to receive forced-air pre-warming at 38ºC for 20 min (the pre-warmed group, n = 25) or not (control group, n = 25) (**Figure 1**). In the pre-anesthetic care unit, tympanic temperature was measured immediately after arrival in the pre-anesthetic care unit and 10 and 20 mins later (Pre-T0, Pre-T10 and Pre-T20, respectively). All patients received 8-10 mL/kg/h of plasma solution for 20 min as pre-hydration, and ambient temperature in the pre-anesthetic care unit was maintained at 21-23ºC.

After a 20-min stay in the pre-anesthetic care unit, patients were transferred to the operating room. Room temperature was set at 24-25ºC, and warming mattress containing circulating water at 36ºC was applied on the operating table. Spinal anesthesia was performed in the lateral decubitus position using 0.5% hyperbaric bupivacaine (10-12 mg intrathecally) by an anesthesiologist unaware of group identities. When systolic blood pressure fell to 80% below the baseline value or to lower than 90 mmHg, phenylephrine (50 μg) or ephedrine (5 mg) was given at 2 min intervals. Room temperature plasma solution was infused at a constant rate of 6 mL/kg/h. All patients were covered with one layer of surgical drapes over chest, thigh, and calves during TURP. Mean arterial pressure, heart rate, patient discomfort to temperature and the occurrence of shivering and of hypothermia were recorded immediately after arrival in the operation room. Hypothermia was defined as a core temperature of < 36ºC. Tympanic temperature was measured at 15-min intervals from spinal anesthesia in the operating room (T0) to 60 min (T60) and from arrival (Post-T0) to 60 min after arrival (Post-T60) in the post-anesthetic care unit. Irrigation fluid for TURP was not warmed. When tympanic temperature fell below 36.0ºC or a patient asked for warming, forced-air warming was supplied regardless of group identity.

Statistical Analysis

The sample size of 25 patients per each group was calculated using power analysis based on the findings of a previous study,[13] in which the overall incidence of hypothermia after neuroaxial anesthesia was found to be 77%. To detect a mean intergroup difference in the incidence of hypothermia, 23 subjects were required with type I error (an α error of 0.05) and type II error (a β error of 0.2), and to account for possible losses, we included 25 patients per group. Statistical Package for the Social Science (SPSS Inc, Chicago, Illinois, USA) version 17.0 was used for the analysis. Results are expressed as numbers of patients or as mean ± SD or median (interquartile range). The independent *t*-test or

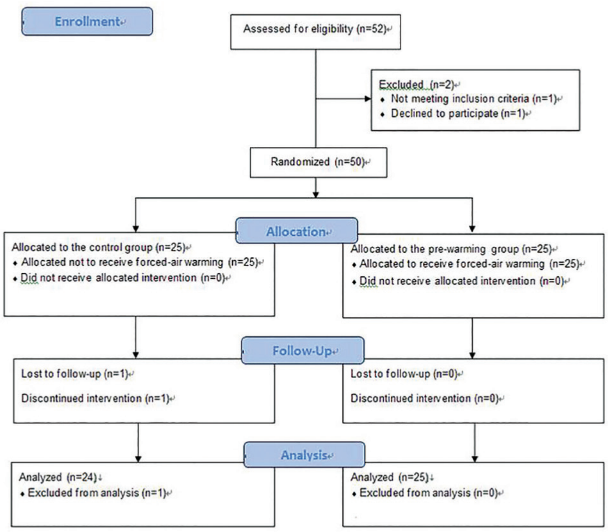

Figure 1. Flow CONSORT diagram

Table 2. Incidences of hypothermia and shivering during the peri-operative period.

Variables	Pre-warmed (n = 25)	Control (n = 24)	*P* Value
Intra-operative period (in OR)			
Normothermia (≥ 36.0ºC)	15 (60)	10 (41)	.259
Hypothermia (< 36.0ºC)	10 (40)	14 (59)	
Severity of hypothermia			.019
Mild (35.5-35.9ºC)	10 (40)	6 (25)	
Moderate (35.0-35.4ºC)	0 (0)	5 (21)	
Profound (34.5-34.9ºC)	0 (0)	3 (13)	
Shivering	5 (20)	8 (33)	.345
Needing rescue warming	3 (12)	3 (13)	.888
Post-operative period (in PACU)			
Hypothermia (< 36.0ºC) on arrival	10 (40)	13 (54)	.321
Shivering	2 (8)	1 (4)	.485
Needing rescue warming	7 (28)	6 (25)	.564
Time required to normothermia (min)	44 ± 23	52 ± 13	.347

Abbreviations: OR, operating room; PACU, post-anesthetic care unit.
Data are expressed as mean ± SD or numbers of patients (%).

the chi-square test was used, as appropriate, to compare variables between the groups, and repeated measures ANOVA was used to compare changes in core temperature between the pre-warmed and control groups. *P* values of less than .05 were considered statistically significant.

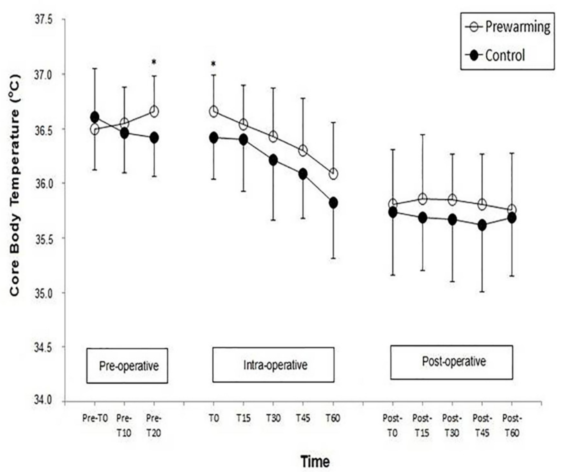

Figure 2. Peri-operative changes in core temperature in patients who received forced-air warming for 20 min (pre-warmed group, ○) or not (control group, ●) during transurethral resection of the prostate. Error bars represent standard deviations. Pre-T0-20, from arrival to 20 min stay in the pre-anesthetic care unit; T0-60, immediately to 60 min after spinal anesthesia; post-T0-60, from arrival to 60 min stay in the post-anesthetic care unit. A significant decrease in core temperature was observed during the intraoperative period (*P* < .001). Core temperature changes were not statistically significantly different in two study groups (*P* = .763).
**P* < .05, control group vs. pre-warmed group.

RESULTS

Twenty-five patients were initially enrolled in each group, but one patient in the control group was excluded from the analysis, because the anesthetic technique was changed to general anesthesia (**Figure 1**). Patient characteristics and peri-operative data are presented in **Table 1**. No significant differences were observed between the two groups in terms of sensory block level, volume of irrigation fluid, or total amount of intravenous fluid infused during TURP.

The incidences of intraoperative hypothermia (< 36ºC) in the pre-warmed and control groups were not statistically significant (10/25 [40%] vs. 15/24 [62.5%], *P* = .259). However, severities of hypothermia were significantly different (*P* = .019); no patient in the pre-warmed group showed moderate or profound hypothermia, whereas of patients in control group 21% and 13% did so, respectively. Frequencies of rescue warming during and after surgery, and the incidences of intra- and postoperative shivering were similar in the two groups (**Table 2**).

Figure 2 illustrates observed changes in core temperature during the perioperative period. During pre- and postoperative periods, the changes in core temperature between the groups were not significantly different (both *P* values > .05). During the intraoperative period, a significant decrease in core temperature (*P* < .001) was observed in both groups, but these changes were not statistically significant (*P* = .763). Mean core temperature was significantly higher in the pre-warmed group at Pre-T20 and at T0 (immediately after spinal anesthesia).

DISCUSSION

In the present study, preoperative forced-air warming for 20 min did not completely prevent intraoperative hypothermia or shivering, but did significantly reduce its severity in elderly male patients undergoing TURP under spinal anesthesia. Several authors have reported that preoperative warming using a forced-air warmer, reduces the risk of core hypothermia and prevents post-anesthesia shivering after general anesthesia or an epidural block,[10,14] and suggested that effective skin surface warming helpfully increases body heat content and reduces the risk of redistribution hypothermia associated with anesthesia. A previous analysis of 19 studies with total 1451 patients suggested that as a single strategy, preoperative forced air warming had significant benefits than other warming methods.[15]

However, studies on pre-warming prior to spinal anesthesia, which might prevent hypothermia or shivering during procedures requiring large volumes of cold irrigation are lacking. Although during neuroaxial block (spinal/epidural anesthesia), heat loss from superficial tissue to the environment is less than during general anesthesia, due to a smaller temperature gradient, the temperature difference between core and superficial tissues is greater during neuroaxial block, and thus, core temperatures could fall due to heat redistribution.[10] Accordingly, skin surface warming should theoretically reduce the core to superficial tissue temperature gradient and possibly prevent redistribution hypothermia.[10] Kim and colleagues[16] demonstrated that skin surface warming during anesthetic preparation could significantly reduce the difference between core and skin temperatures in patients undergoing coronary artery bypass graft. In the present study, skin surface warming for 20 min significantly reduced the severity of hypothermia, but not its incidence. We believe this is probably due to age-related decreases in thermoregulatory functions, such as, vasoconstriction and shivering. In the elderly, reduced norepinephrine release and the down-regulation of α-adrenoreceptors impair vasomotor response to cold. Furthermore, loss of lean body mass due to aging reduces shivering, and thus, metabolic heat generation.[17] In fact, with the exception of block level, an advanced age is the most significant predictor of core hypothermia during spinal anesthesia.[4] In the present study, we enrolled patients aged over 65 years old in view of the fact that the vasoconstrictive threshold is about 0.8ºC lower in those aged 60-80 years than in those aged 30-50 years (35.0ºC vs 35.8ºC).[18] Because of these thermoregulatory changes in elderly patients, pre-operative skin surface warming for 20 min is probably not sufficient to maintain a core body temperature of > 36ºC during TURP in the present study.

Furthermore, spinal anesthesia per se alters afferent thermal inputs and impairs thermoregulatory responses, and thresholds of shivering and vasoconstriction decrease by 0.5-0.9ºC during spinal anesthesia.[1,19] In this study, we observed median maximal falls in core temperatures of 0.4ºC and 0.5ºC in the pre-warmed and control groups, respectively. Furthermore, presumably because spinal anesthesia might decrease thermoregulatory thresholds further in the elderly, observed incidences of post-anesthesia shivering were relatively low (25% and 33% in the pre-warmed and control groups, respectively) as compared with those of intra-operative hypothermia (40% and 62.5% in the pre-warmed and control groups, respectively).

The restriction of the study population to elderly males is the main limitation of the present study. Thermal responses to exogenous and endogenous heat losses differ between the sexes, because body surface to body mass ratios, subcutaneous fat contents, and exercise capacities differ.[20] Furthermore, in a recent study, it was found that the incidence of postoperative shivering was higher in elderly females than in elderly males.[21] Thus, our results cannot be generalized to elderly females, and further study is needed to elucidate the effect of pre-operative forced-air warming on hypothermia or shivering in female patients. Another limitation in this study is that tympanic temperature alone might not guarantee the accurate core body temperature. Gilbert and colleagues[22] demonstrated that additional use of digital oral thermometer to tympanic thermometer could provide valid patients' temperature. However, another previous study has reported that oral or tympanic temperature frequently over- or underestimate the rectal temperature.[23] Additionally, if we have measure the skin temperatures on limbs and trunk in addition to core temperature, we could estimate mean body temperature and calculate total heat body content, based on previously reported formula.[24] However, we did not measure the skin temperatures, because applying forced air warming device would interfere with the accurate measurement of skin temperatures. Meanwhile, we could calculate mean energy input in the pre-warmed group, since the heat capacity of human body is 0.812 kcal/kg ºC,[25] which means that to change the body temperature of a 60 kg human by ºC, 49 kcal is needed. In this study, mean patient weight was 63 kg, mean elevation in core temperature in the pre-warmed group was 0.2°C, and mean energy input in the pre-warmed group was about 10 kcal for 20 mins.

CONCLUSIONS

In conclusion, in elderly male patients during TURP under spinal anesthesia, pre-operative forced-air warming for 20 min significantly reduced the severity but not the incidence of intraoperative hypothermia. We suggest that only short-time skin surface warming could reduce somewhat the severity of redistribution hypothermia in elderly male patients.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Ozaki M, Kurz A, Sessler DI, et al. Thermoregulatory thresholds during epidural and spinal anesthesia. Anesthesiology. 1994;81:282-8.
2. Matsukawa T, Sessler DI, Christensen R, Ozaki M, Schroeder M. Heat flow and distribution during epidural anesthesia. Anesthesiology. 1995;83:961-7.
3. Vassilieff N, Rosencher N, Sessler DI, Conseiller C. Shivering threshold during spinal anesthesia is reduced in elderly patients. Anesthesiology. 1995;83:1162-6.
4. Frank SM, El-Rahmany HK, Cattaneo CG, Conseiller C. Predictors of hypothermia during spinal anesthesia. Anesthesiology. 2000;92:1330-4.
5. Frank SM, Beattie C, Christopherson R, et al. Unintentional hypothermia is associated

with postoperative myocardial ischemia. The Perioperative Ischemia Randomized Anesthesia Trial Study Group. Anesthesiology. 1993;78:468-76.

6. Schmied H, Kurz A, Sessler DI, Kozek S, Reiter A. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. Lancet. 1996;347:289-92.
7. Kurz A, Sessler DI, Lenhardt R. Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. Study of wound infection and temperature group. N Engl J Med. 1996;334:1209-15.
8. Moorthy HK, Philip S. TURP syndrome - current concepts in the pathophysiology and management. Indian J Urol. 2001;17:97-102.
9. Pit MJ, Tegelaar RJ, Venema PL. Isothermic irrigation during transurethral resection of the prostate: effects on peri-operative hypothermia, blood loss, resection time and patient satisfaction. Br J Urol. 1996;78:99-103.
10. Glosten B, Hynson J, Sessler DI, McGuire J. Preanesthetic skin-surface warming reduces redistribution hypothermia caused by epidural block. Anesth Analg. 1993;77:488-93.
11. Horn EP, Bein B, Böhm R, Steinfath M, Sahili N, Höcker J. The effect of short time periods of pre-operative warming in the prevention of peri-operative hypothermia. Anaesthesia. 2012;67:612-7.
12. de Brito Poveda V, Clark AM, Galvão CM. A systematic review on the effectiveness of prewarming to prevent perioperative hypothermia. J Clin Nurs. 2013;22:906-18.
13. Arkiliç CF, Akça O, Taguchi A, Sessler DI, Kurz A. Temperature monitoring and management during neuraxial anesthesia: an observational study. Anesth Analg. 2000;91:662-6.
14. Andrzejowski J, Hoyle J, Eapen G, Turnbull D. Effect of prewarming on post-induction core temperature and the incidence of inadvertent perioperative hypothermia in patients undergoing general anaesthesia. Br J Anaesth. 2008;101:627-31.
15. Kim JY, Shinn H, Oh YJ, Hong YW, Kwak HJ, Kwak YL. The effect of skin surface warming during anesthesia preparation on preventing redistribution hypothermia in the early operative period of off-pump coronary artery bypass surgery. Eur J Cardiothorac Surg. 2006;29:343-7.
16. Moola S, Lockwood C. Effectiveness of strategies for the management and/or prevention of hypothermia within the adult perioperative environment. Int J Evid Based Healthc. 2011;9:337-45.
17. Frank SM, Raja SN, Bulcao C, Goldstein DS. Age-related thermoregulatory differences during core cooling in humans. Am J Physiol Regul Integr Comp Physiol. 2000;279:R349-54.
18. Ozaki M, Sessler DI, Matsukawa T, et al. The threshold for thermoregulatory vasoconstriction during nitrous oxide/sevoflurane anesthesia is reduced in the elderly. Anesth Analg. 1997;84:1029-33.
19. Kurz A, Sessler DI, Schroeder M, Kurz M. Thermoregulatory response thresholds during spinal anesthesia. Anesth Analg. 1993;77:721-6.
20. Gagnon D, Kenny GP. Does sex have an independent effect on thermoeffector responses during exercise in the heat? J Physiol. 2012;590:5963-73.
21. Conti D, Ballo P, Boccalini R, et al. The effect of patient sex on the incidence of early adverse effects in a population of elderly patients. Anaesth Intensive Care. 2014;42:455-9.
22. Gilbert M, Barton AJ, Counsell CM. Comparison of oral and tympanic temperatures in adult surgical patients. Appl Nurs Res. 2002;15:42-7.
23. Barnett BJ, Nunberg S, Tai J, et al. Oral and tympanic membrane temperatures are inaccurate to identify fever in emergency department adults. West J Emerg Med. 2011;12:505-11.
24. Lenhardt R, Sessler DI. Estimation of mean body temperature from mean skin and core temperature. Anesthesiology. 2006;105:1117-21.
25. Belani K, Sessler DI, Sessler AM, et al. Leg heat content continues to decrease during the core temperature plateau in humans anesthetized with isoflurane. Anesthesiology. 1993;78:856-63.