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Predictors of Hypothermia during Spinal Anesthesia

Steven M. Frank, M.D., Hossam K. El-Rahmany, M.D.,† Christine G. Cattaneo, M.D.,‡ Rachel A. Barnes, M.A.§*

Background: **Body temperature often is ignored during regional anesthesia, despite evidence that hypothermia occurs commonly. Because hypothermia is associated with adverse clinical outcomes, it is important to recognize predictors of hypothermia and to monitor and control body temperature in patients at risk. The current study was designed to determine the predictors of core hypothermia in patients receiving spinal anesthesia for radical retropubic prostatectomy.**

Methods: **Forty-four patients undergoing radical retropubic prostatectomy were studied. A lumbar intrathecal injection of 18–22 mg bupivacaine, 0.75%, with 20 μg fentanyl was given. No active warming measures were used other than intravenous fluid warming. The following clinical variables were assessed as potential predictors of core (tympanic) temperature at admission to the postanesthesia care unit: duration of surgery, average ambient operating room temperature, body habitus, age, and spinal blockade level.**

Results: **The mean core temperature at admission to the postanesthesia care unit was 35.1 ± 0.6°C (range, 33.6–36.3°C). Duration of surgery, ambient operating room temperature, and body habitus were not predictors of hypothermia. A high level of spinal blockade and increasing age were predictors of hypothermia. For each incremental increase in block level, core temperature decreased by 0.15°C, and for each increase in age, core temperature decreased by 0.3°C.**

Conclusions: **Although high-level spinal blockade has been associated with decreased thermoregulatory thresholds, no previous study has shown that a higher level of blockade is associated with a greater magnitude of core hypothermia in the clinical setting. As with general anesthesia, advanced age is associated with hypothermia during spinal anesthesia. (Key words: Body temperature; regional anesthesia; thermoregulation.)**

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* Associate Professor, the Department of Anesthesiology and Critical Care Medicine, The Johns Hopkins Medical Institutions.

† Postdoctoral Fellow, the Department of Anesthesiology and Critical Care Medicine, The Johns Hopkins Medical Institutions.

‡ Instructor, the Department of Anesthesiology and Critical Care Medicine, The Johns Hopkins Medical Institutions.

§ Medical Student, University of Maryland School of Medicine, Baltimore, Maryland.

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Address reprint requests to Dr. Frank: Department of Anesthesiology and Critical Care Medicine, The Johns Hopkins Hospital, Carnegie 280, 600 North Wolfe Street, Baltimore, Maryland 21287. Address electronic mail to: sfrank@welch.jhu.edu

MAJOR conduction blockade significantly impairs the regulation of body temperature by inhibition of vasomotor and shivering responses[1] and by redistribution of heat from the core of the body to peripheral tissues. These effects predispose patients to development of hypothermia during regional anesthesia, which may be as common and severe as during general anesthesia.[3,4] Because monitoring of body temperature is not practiced commonly during regional anesthesia,[5] hypothermia goes unrecognized in a significant number of patients.[6] Because perioperative hypothermia is associated with adverse clinical outcomes (infection,[7] bleeding,[8] cardiac injury,[9] discomfort,[10] and shivering[11]), it is important to recognize the clinical predictors of hypothermia and to monitor and control body temperature carefully in patients at risk.

Multiple studies have identified risk factors for hypothermia in patients receiving general anesthesia, including advanced age,[12] low ambient temperature,[13] and decreased lean body mass.[14] During spinal anesthesia, however, the clinical predictors of hypothermia may be different, because the center of thermoregulatory control (*i.e.*, the hypothalamus) is not affected directly, and changes in vasomotor tone follow a different pattern. We performed the current study in to determine the predictors of core hypothermia in patients receiving spinal anesthesia.

Materials and Methods

After obtaining institutional review board approval and written informed patient consent, 44 patients scheduled

for radical retropubic prostatectomy were enrolled. Exclusion criteria were preoperative fever (> 38.0°C), hypo- or hyperthyroidism, or any dysautonomia syndrome. Percentage body fat was measured using the infrared interactance method over the biceps skin fold.[15]

The anesthetic technique consisted of 1 or 2 mg midazolam administered intravenously at arrival in the operating room, and a lumbar intrathecal injection of 18–22 mg bupivacaine, 0.75%, in 7.5% dextrose solution with 20 μg fentanyl. Blood transfusions were administered to maintain hemoglobin concentration above 10 g/dl. Blood was given through an in-line warmer and warmed to 38°C. Crystalloid solutions were preheated to 37°C in a warmed cabinet and given without in-line warming. No other warming device was used. All patients were covered with one layer of paper surgical drapes and one layer of cotton blanket positioned over the thighs and calves. In addition, one layer of cotton blanket was placed over the chest and arms. Spinal block level was assessed by testing for the loss of pinprick sensation just before skin incision, approximately 20–25 min after spinal injection. Ambient temperature in the operating room was not controlled by protocol.

Temperature Monitoring

All temperatures were measured using thermocouple probes (Mon-a-therm; Mallinckrodt Medical, St. Louis, MO) and recorded every 1 min by an electronic data-acquisition system (Iso-thermex; Columbus Instruments, Columbus, OH). Core temperature was measured at the tympanic membrane with a cotton-tipped probe inserted to a depth that elicited a slight scratching sound reported by the patient. The external auditory canal was packed with cotton for insulation. Ambient temperature also was measured using thermocouples placed near the patient but away from any heat-generating equipment. The ambient temperature was averaged over the entire intraoperative course, using measurements taken at 5-min intervals. Monitoring was begun just before the spinal injection. After admission to the postanesthesia care unit (PACU), temperature monitoring was continued for 3 h. From the electronically recorded temperature data, temperatures taken at specific time points were analyzed. These times were before the spinal injection and 15, 30, and 45 min afterward; at the time of prostate removal; 15 and 30 min after prostate removal; at the end of surgery; and in the PACU at 0, 15, 30, 45, 60, 90, 120, 150, and 180 min after admission.

Clinical variables that were assessed as predictors of core temperature at admission to the PACU were duration of surgery, ambient operating room temperature, body mass, body mass index (kg/m^2), percentage body fat, age, and height of spinal blockade.

Table 1. Demographic Data

Variable	Mean ± SD	Range
Age (yr)	57 ± 7	47–67
Body weight (kg)	88 ± 20	70–120
Height (cm)	180 ± 13	168–194
Body fat (%)	27 ± 7	13–39
Body mass index (kg/m^2)	27.3 ± 14	21.5–35.6
Block height (dermatome level)	T5 ± 3	T3–T8
Ambient OR temperature (°C)	20.9 ± 0.13	18.7–22.9
Duration of surgery (min)	92 ± 54	65–155
Estimated blood loss (ml)	1100 ± 360	400–2,500
Blood transfused (U)	0.7 ± 0.5	0–3

Statistical Analysis

Changes in core temperature over time were analyzed by analysis of variance with repeated measures. Univariate predictors of core temperature at admission to the PACU were determined by simple linear regression. Multivariate predictors were determined by multiple linear regression with backward elimination,[16] retaining all variables in the model with $P > 0.12$. $P < 0.05$ defined significance, and all data are expressed as the mean ± SD.

Results

The demographic data are given in table 1. All patients were male, with a normal distribution of age and morphometric characteristics for a patient population undergoing radical prostate surgery.

During the initial 45 min after the spinal was administered, core temperature decreased rapidly to more than 1°C below the preoperative baseline (fig. 1). By the end of the surgical procedure, mean core temperature was 1.5°C below the preoperative baseline value. Mean core temperature at admission to the PACU was 35.1 ± 0.6°C (range, 33.6–36.3). Rewarming was slow in the postoperative period, in which patients were allowed to rewarm passively.

Predictors of core temperature at admission to the PACU were identified by univariate and multivariate analyses (table 2). Duration of surgery, ambient operating room temperature, body mass, body mass index, and percentage body fat were not significant predictors of hypothermia. A high level of spinal blockade and advanced age were predictors of low core temperature by both univariate and multivariate tests. Figure 2 shows

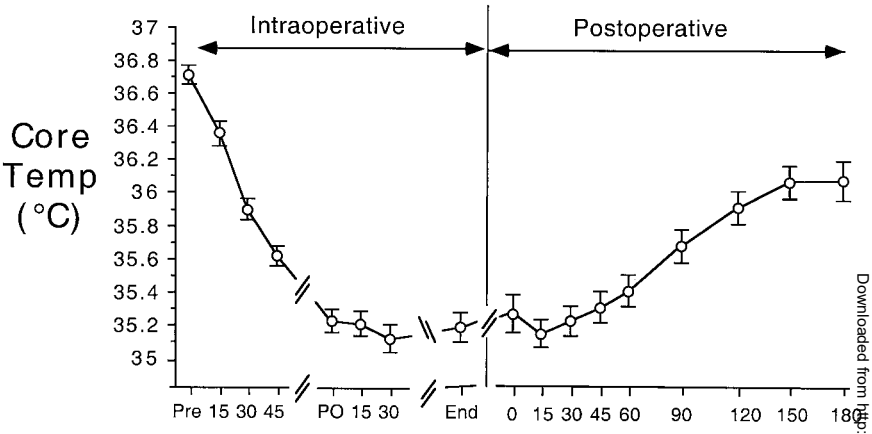

Fig. 1. Core temperature (tympanic) decreases immediately after onset of spinal anesthesia, and rewarming is slow in the postoperative period. Values on the *x*-axis represent minutes. Data are expressed as the mean ± SEM. Pre = before spinal; PO = prostate out; End = end of surgery.

the associations of age and level of spinal blockade with core temperature at admission to the PACU.

The regression equations describing the effects of age and block level were, respectively, as follows: core temperature (°C) = 34.37 + (0.15 · dermatomal block level), and core temperature (°C) = 36.72 − (0.03 · age in yr). The effect of increasingly high block level, therefore, was a 0.15°C decrease in core temperature for each additional dermatomal level. For each year of increasing age there was a 0.03°C decrease in core temperature.

Of the five surgeons whose patients were involved in the study, one routinely used a smaller incision (≈ 10–12 cm) compared with the others (≈ 20–25 cm). Seven of the 44 patients were operated on by this surgeon. Demographically, these patients were no different from the other patients in age, height, weight, duration of surgery, ambient temperature, amount of blood loss, or height of spinal block. Mean core temperature at admission to the PACU was similar between patients of this surgeon (34.9 ± 0.5°C) and those of the other surgeons (35.1 ± 0.6°C; $P = 0.77$).

Discussion

Although advanced age and high level of spinal blockade were significant predictors of core hypothermia during spinal anesthesia, other variables (ambient temperature, body habitus, amount of blood loss, and duration of surgery) were not predictors of changes in core temperature. High levels of spinal blockade are known to decrease the core temperature threshold for shivering,[17] but no previous study has shown a high level of blockade to be associated with a greater magnitude of core hypothermia in the clinical setting. As with general anesthesia,[18] advanced age is a risk factor for hypothermia during spinal anesthesia, but in contrast to general anesthesia, body habitus and ambient operating room temperature (within the range reported) were not predictors of hypothermia.

The correlation between high-level spinal blockade and low core temperature during spinal anesthesia is consistent with the known physiologic effects of spinal anesthesia. Both vasomotor tone and shivering are inhibited below the level of the spinal block through sympathetic and somatic neural blockade, respectively.[19] The greater the proportion of the body that is blocked, the more impairment of thermoregulatory function is to be expected. In support of this is the study by Leslie and Sessler,[17] which showed a decreased shivering threshold in proportion with the level of spinal blockade. These investigators showed that core temperature threshold was decreased by 0.06°C for each dermatomal level that was blocked. Our study confirms the findings of Leslie and Sessler[17] in the clinical setting by demonstrating

Table 2. Predictors of Hypothermia during Spinal Anesthesia

Variable	*P* Value	
	Univariate	Multivariate
Ambient OR temperature (°C)	0.69	0.70
Duration of surgery (min)	0.62	0.22
Body mass index (kg/m^2)	0.22	*
Body weight (kg)	0.42	0.14
Body fat (%)	0.19	0.14
Age (yr)	0.04	0.01
Block level	0.004	0.002

* When body mass index was included in the regression model along with percent body fat, the model became unstable. Body mass index was therefore not included in the multivariate analysis.

OR = operating room.

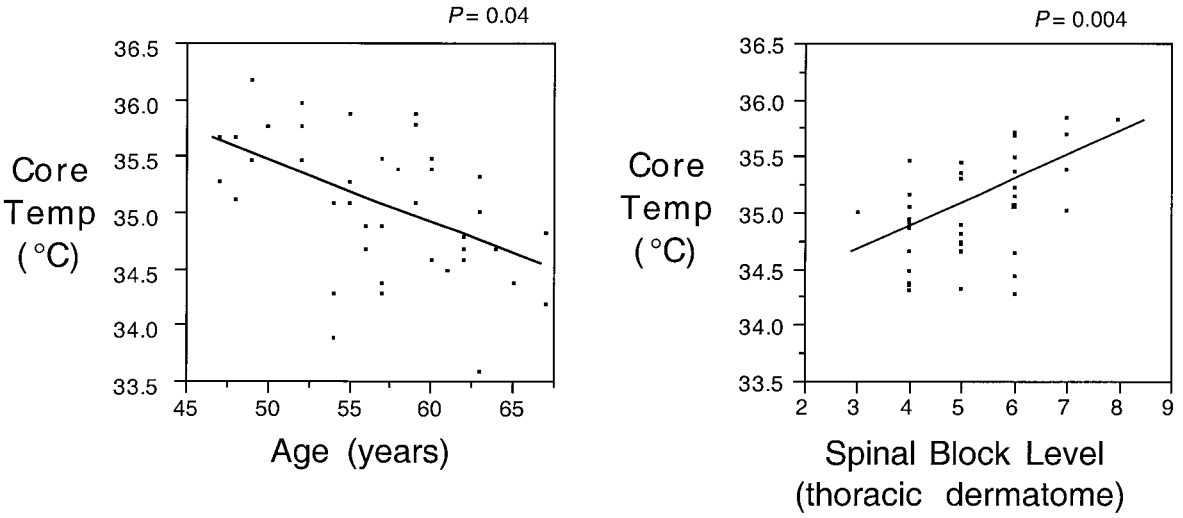

Fig. 2. Advanced age and high level of spinal block were significant predictors of core hypothermia at admission to the postanesthesia care unit by linear regression.

high block level to be a risk factor for core hypothermia. In our analysis, for each additional dermatomal level of spinal blockade there was a decrease of 0.15°C for predicted core temperature at admission to the PACU.

It is conceivable that factors associated with higher levels of blockade caused increased hypothermia and that blockade level, *per se*, was not the cause. For example, fluid and blood requirements are sometimes greater with higher block levels. Because fluids and blood were warmed to body temperature before administration, however, the chances of such a confounding effect are minimal. In addition, there was no relation between blockade level and actual fluid and blood requirements.

The magnitude of core hypothermia in the current study was similar to that reported in previous studies during general anesthesia.[8,9,20] Some studies that have compared core temperature during general and regional anesthesia indicate a similar incidence and magnitude of hypothermia.[4,21] Thus, although there are different physiologic mechanisms for thermoregulatory inhibition during general and regional anesthesia (central *vs.* peripheral nervous system effects, respectively), patients are at significant risk for hypothermia during spinal anesthesia, especially if the level of spinal block is high.

According to a recent survey, it is not common practice to monitor body temperature during regional anesthesia.[5] Reasons for this include the absence of risk for malignant hyperthermia and the lack of a convenient and reliable site for temperature-probe insertion. Hypothermia therefore often is neither recognized nor treated in patients receiving regional anesthetic techniques.[6] Even if patients are awake, they are unlikely to report the sensation of cold because there is an "apparent" warm input from the portion of the body below the level of neural blockade.[22] Often the first manifestation of hypothermia occurs postoperatively, when the spinal block is resolving and patients feel cold and start to shiver. Unfortunately, in this circumstance hypothermia often is treated rather than prevented.

Ambient temperature was not a predictor of hypothermia during spinal anesthesia, despite the fact that it is a known predictor during general anesthesia.[13] It is possible that the effect of ambient temperature was underestimated in the current study because the range of ambient temperature may not have been great enough to show an effect. The range in this study, however, was not different than the range in previous studies using general anesthesia.[23] Further studies are needed to show the ambient temperature required to prevent hypothermia during spinal anesthesia. Body habitus and duration of surgery also were not predictors of hypothermia. It may be that the intense vasodilation associated with spinal blockade is accompanied by rapid and significant heat loss, which results in hypothermia regardless of the other factors (ambient temperature, body habitus, and duration of surgery).

In the current study we did not find a relation between surgical incision size and core temperature. Although there was no randomization or control group, it appears

that heat loss through the incision represents a small proportion of total heat loss in patients receiving spinal anesthesia. A larger sample size is required to determine the effects of incision size with greater certainty.

High-level spinal blockade has known complications such as respiratory and hemodynamic compromise. In addition to these complications, there is an increased risk of hypothermia. Clinical implications are to limit the spinal block height to the level that is necessary for the surgery and to carefully monitor and control body temperature in older patients and in those patients with high-level blocks during spinal anesthesia.

References

1. Ozaki M, Kurz A, Sessler DI, Lenhardt R, Schroeder M, Moayeri A, Noyes KM, Rotheneder E: 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: The shivering threshold during spinal anesthesia is reduced in the elderly. ANESTHESIOLOGY 1995; 83:1162–6

4. Frank SM, Shir Y, Raja SN, Fleisher LA, Beattie C: Core hypothermia and skin-surface temperature gradients: Epidural vs. general anesthesia and the effects of age. ANESTHESIOLOGY 1994; 80:502–8

5. Frank SM, Nguyen JM, Garcia CM, Barnes RA: Temperature monitoring practices during regional anesthesia. Anesth Analg 1999; 88: 373–7

6. Arkilic CF, Akca O, Scheck T, Kurz A, Sessler DI: Hypothermia is common during neuraxial anesthesia and is frequently undetected by both anesthesiologists and patients (abstract). ANESTHESIOLOGY 1999; 91:A531

7. Kurz A, Sessler DI, Lenhardt R, the Study of Wound Infection, Temperature Group: Perioperative normothermia to reduce the incidence of surgical-wound infection and shorten hospitalization. N Engl J Med 1996; 334:1209–15

8. 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

9. Frank SM, Fleisher LA, Breslow MJ, Higgins MS, Olson KF, Kelly S, Beattie C: Perioperative maintenance of normothermia reduces the incidence of morbid cardiac events: A randomized trial. JAMA 1997; 277:1127–34

10. Kurz A, Sessler DI, Narzt E, Bekar A, Lenhardt R, Huemer G: Postoperative hemodynamic and thermoregulatory consequences of intraoperative core hypothermia. J Clin Anesth 1995; 7:359–66

11. Frank SM, Fleisher LA, Olson KF, Gorman RB, Higgins MS, Breslow MJ, Sitzmann JV, Beattie C: Multivariate determinates of early postoperative oxygen consumption: The effects of shivering, core temperature, and gender. ANESTHESIOLOGY 1995; 83:241–9

12. Vaughan MS, Vaughan RW, Cork RC: Postoperative hypothermia in adults: Relationship of age, anesthesia, and shivering in rewarming. Anesth Analg 1981; 60:746–51

13. Morris RH: Operating room temperature and the anesthetized paralyzed patient. Arch Surg 1971; 103:95

14. Kurz A, Sessler DI, Narzt E, Lenhart R: Morphometric influences on intraoperative core temperature changes. Anesth Analg 1995; 80: 562–7

15. Conway JM, Norris KH, Bodwell CE: A new approach for the estimation of body composition: Infrared interactance. Am J Clin Nutr 1984; 40:1123–30

16. Draper NR, Smith H: Applied Regression Analysis, 2nd edition. New York, John Wiley and Sons, 1981

17. Leslie K, Sessler DI: Reduction in the shivering threshold is proportional to spinal block height. ANESTHESIOLOGY 1996; 84:1327–35

18. Kurz A, Plattner O, Sessler DI, Huemer G, Redl G, Lackner F: The threshold for thermoregulatory vasoconstriction during nitrous oxide-isoflurane anesthesia is lower in elderly than in young patients. ANESTHESIOLOGY 1993; 79:465–9

19. Kurz A, Sessler DI, Schroeder M, Kurz M: Thermoregulatory response thresholds during spinal anesthesia. Anesth Analg 1993; 77: 721–6

20. Lenhardt R, Marker E, Goll V, Tschernich H, Kurz A, Sessler DI, Narzt E, Lackner F: Mild intraoperative hypothermia prolongs postanesthetic recovery. ANESTHESIOLOGY 1997; 87:1318–23

21. Jenkins J, Fox J, Sharwood-Smith G: Changes in body heat during transvesical prostatectomy: A comparison of general and epidural anaesthesia. Anaesthesia 1983; 38:748–53

22. Emerick TH, Ozaki M, Sessler DI, Walters K, Schroeder M: Epidural anesthesia increases apparent leg temperature and decreases the shivering threshold. ANESTHESIOLOGY 1994; 81:289–98

23. Frank SM, Beattie C, Christopherson R, Norris EJ, Rock P, Parker S, Kimball AW: Epidural versus general anesthesia, ambient operating room temperature, and patient age as predictors of inadvertent hypothermia. ANESTHESIOLOGY 1992; 77:252–7