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Spinal Anesthesia Speeds Active Postoperative Rewarming

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Background: **Redistribution of body heat decreases core temperature more during general than regional anesthesia. However, the combination of anesthetic- and sedative-induced inhibition may prevent effective upper-body thermoregulatory responses even during regional anesthesia. The extent to which each type of anesthesia promotes hypothermia thus remains controversial. Accordingly, the authors evaluated intraoperative core hypothermia in patients assigned to receive spinal or general anesthesia. They also tested the hypothesis that the efficacy of active postoperative warming is augmented when spinal anesthesia maintains vasodilation.**

Methods: **Patients undergoing lower abdominal and leg surgery were randomly assigned to receive general anesthesia (isoflurane and nitrous oxide; n = 20) or spinal anesthesia (bupivacaine; n = 20). Fluids were warmed to 37°C and patients were covered with surgical drapes. However, no other active warming was applied during operation. Ambient temperatures were maintained near 20°C. After operation, patients were warmed with a full-length, forced-air cover set to 43°C. Shivering, when observed, was treated with intravenous meperidine.**

Results: **The mean spinal analgesia level, which was at the sixth thoracic level during surgery, remained at the T12 dermatome after 90 min after operation. Core temperatures did not differ significantly during surgery and decreased to 34.4 ± 0.5°C and 34.1 ± 0.4°C, respectively, in patients given spinal and general anesthesia. After operation, however, core temperatures increased significantly faster (1.2 ± 0.1°C/h *vs.* 0.7 ± 0.2°C/h, mean ± SD; $P < 0.001$) in patients given spinal anesthesia. Consequently, patients given spinal anesthesia required less time to rewarm to 36.5°C (122 ± 28 min *vs.* 199 ± 28 min; $P < 0.001$).**

Conclusions: **Comparable intraoperative hypothermia during general and regional anesthesia presumably resulted because the combination of spinal anesthesia and meperidine administration obliterated effective peripheral and central thermoregulatory control. Vasodilation increased the rate of core rewarming in patients after operation with residual lower-body sympathetic blocks, suggesting that vasoconstriction decreased peripheral-to-core heat transfer after general anesthesia. (Key words: Anesthesia: general; spinal. Hypothermia. Thermoregulation. Temperature: core; tissue. Warming techniques: forced air.)**

IT would be difficult to predict the relative effects of general and regional anesthesia on intraoperative core temperature from previous heat-balance studies. More heat is redistributed after general[1] than regional[2] anesthesia, for example, but intraoperative heat loss otherwise is likely to be comparable. Patients undergoing regional anesthesia might be better able to activate thermoregulatory defenses than those having general anesthesia; however, the combination of anesthetic-induced[3,4] and sedative-induced[5-7] inhibition may be sufficient to prevent responses in most patients. Furthermore, the benefit of thermoregulatory defenses—once triggered—may be modest because vasoconstriction and shivering are restricted to the upper body during major conduction anesthesia.

Some studies conclude that core temperature de-

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creases more during general anesthesia,[8] whereas others suggest that hypothermia is comparable with each technique.[9,10] An additional study concluded that hypothermia was greater during general anesthesia, but only when surgery was conducted in a (typical) cool environment.[11] Therefore, we evaluated intraoperative core hypothermia in patients assigned to receive spinal or general anesthesia. We evaluated patients undergoing relatively extensive operations in a cool environment because these patients are most susceptible to hypothermia.

Active intraoperative cutaneous warming is effective, rapidly increasing core temperature and body heat content.[12,13] Facile intercompartmental transfer of heat during surgery is likely to result from both centrally mediated inhibition of thermoregulatory control[7,14] and direct, peripheral vasodilation induced by volatile anesthetics.[15] Active postoperative warming, in contrast, is sometimes no more effective than passive insulation.[16,17,#] These observations suggest that vasoconstriction isolates the thermal compartments, thus impairing flow of peripherally applied heat to core tissues.[18] Recovery from spinal and general anesthesia differs in that residual sympathetic nerve block maintains lower-body vasodilation after spinal anesthesia. Residual spinal anesthesia thus seems likely to facilitate postoperative core rewarming. Accordingly, we tested the hypothesis that active cutaneous warming increases core temperature significantly faster in patients recovering from spinal than general anesthesia.

Materials and Methods

With institutional review board approval and written consent, we evaluated 40 patients categorized as American Society of Anesthesiologists physical status I and II who were 20–80 yr old. All were scheduled for orthopedic surgery, vaginal hysterectomy, or femoropopliteal bypass. Patients with thyroid diseases, dysautonomia, Raynaud's syndrome, or malignant hyperthermia were excluded from the study.

Protocol

During surgery, ambient temperature was maintained at 20–21°C and no active patient warming was used. Patients were, however, covered with surgical draping in the usual manner. Intravenous fluids were warmed to 37°C. Patients were then randomly assigned to one of the two groups: general anesthesia or spinal anesthesia. Patients assigned to spinal anesthesia were given an intravenous loading dose of 10 ml/kg warmed Ringer's lactate solution. A subarachnoid needle was inserted at the L3-4 interspace, and 3 ml 0.5% isobaric bupivacaine was injected. Patients assigned to receive general anesthesia were pretreated with oxygen. General anesthesia was induced with 0.5 mg/kg meperidine, 4 mg/kg thiopental, and 1.5 mg/kg succinylcholine. Anesthesia was subsequently maintained with isoflurane (0.8–1.0%), vecuronium, and 60% nitrous oxide in oxygen. The lungs were mechanically ventilated to maintain the end-tidal pressure of carbon dioxide near 35 mmHg.

In both groups of patients, boluses of meperidine (10–20 mg) were administered at the discretion of the attending anesthesiologist and as necessary to treat surgical pain or shivering.[5] After operation, all patients were covered with a full-length, forced-air blanket connected to a heater set at the highest level (≈43°C).[13]

Measurements

Core temperature was measured at the tympanic membrane using Mon-a-Therm thermocouples (Mallinckrodt Anesthesiology Products, St. Louis, MO). The aural probe was inserted by patients until they felt the thermocouple touch the tympanic membrane; appropriate placement was confirmed when patients easily detected a gentle rubbing of the attached wire. The aural canal was occluded with cotton, the probe securely taped in place, and a gauze bandage positioned over the external ear. Ambient temperature was recorded at the level of the patients, well away from any heat-producing equipment.

Morphometric and demographic data were recorded for each participant, as were details of surgical and anesthetic management. Blood pressures and heart rates were evaluated noninvasively. In patients assigned to receive spinal anesthesia, the level of the sensory blockade was detected by pin prick. Postoperative shivering was evaluated by observers blinded to group assignment and core temperature. All results were recorded at 15-min intervals.

Data Analysis

The end of anesthesia was designated elapsed time zero. Demographic and morphometric characteristics, anesthetic management, and rewarming times (to 36.5°C) were compared using two-tailed, unpaired *t*

Mort TC, Rintel TD, Altman F: Shivering in the cardiac patient: Evaluation of the Bair Hugger warming system [Abstract]. ANESTHESIOLOGY 1990; 73:A239.

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Table 1. Temperatures and Anesthetic Management in Patients Given General and Spinal Anesthesia

	General	Spinal
Age (yr)	60 ± 7	63 ± 10
Sex (M/F)	13/7	7/13
Weight (kg)	79 ± 12	72 ± 13
Height (cm)	169 ± 8	166 ± 8
Operating room temperature (°C)	20.4 ± 0.5	20.2 ± 0.4
Duration of surgery (min)	164 ± 23	156 ± 20
Intraoperative fluid (L)	1.7 ± 0.6	1.7 ± 0.7
Intraoperative meperidine (mg)	60 ± 15*	4 ± 9
Postoperative fluid (L)	0.4 ± 0.1	0.4 ± 0.1
Shivering (episodes/patient)	0.5 ± 0.6	0.5 ± 0.9
Postoperative meperidine (mg)	25 ± 23	83 ± 24*
Warming time (min)	199 ± 28	122 ± 28*

Patients given spinal anesthesia rewarmed more quickly to a core temperature of 36.5°C than those given general anesthesia.

* $P < 0.01$.

tests. Postoperative rewarming rates (from 15 to 90 elapsed min) were determined in each patient using linear regression and subsequently compared using unpaired t tests. Results are presented as means ±SD; $P < 0.01$ identified significant differences.

Results

Demographic and morphometric characteristics of the patients in each treatment group were similar. The surgical procedures were also similar in the two groups, with total hip replacement performed in 37% of the cases and femoropopliteal bypass performed in 18%. The remaining cases were vaginal hysterectomies or closed or open fixation of femoral or tibial fractures. The mean spinal analgesia level was at the sixth thoracic level during surgery (T6 ± 1 segment) and decreased to the T10 ± 2, T11 ± 1, and then T12 ± 1 segment, respectively, 30, 60, and 90 min after operation.

Operating room temperatures, duration of surgery, intraoperative and postoperative fluid volumes, and the number of observed postoperative shivering episodes were similar in patients given general and spinal anesthesia. The patients given general anesthesia received significantly more intraoperative meperidine, whereas those given spinal anesthesia required significantly more postoperative meperidine. However, total meperidine use was comparable in each group (table 1). We found no significant differences in heart rates or blood pressures in the two patient groups.

Core temperatures did not differ significantly during surgery and decreased to 34.4 ± 0.5°C and 34.1 ± 0.4°C, respectively, in patients given spinal and general anesthesia. After operation, however, core temperatures increased significantly faster (1.2 ± 0.1°C/h *vs.* 0.7 ± 0.2°C/h; $P < 0.001$) in patients given spinal anesthesia. Consequently, patients given spinal anesthesia required less time to rewarm to 36.5°C (122 ± 28 *vs.* 199 ± 28 min; $P < 0.001$; figure 1).

Discussion

Behavioral[19,20] and central[4,21] thermoregulatory impairment during epidural or spinal anesthesia indicates that substantial core hypothermia may fail to provoke thermoregulatory defenses. Even after being triggered, the peripheral effects of regional anesthesia make autonomic defenses relatively ineffective because lower-body shivering and vasoconstriction are usually prevented. In our patients, shivering was specifically prevented by meperidine administration.[5] Their only remaining defense thus was upper body vasoconstriction. Vasoconstriction limited to this small region

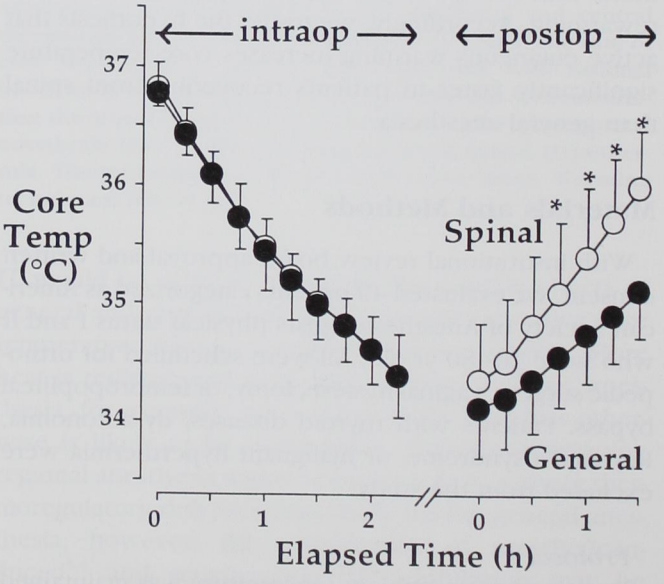

Fig. 1. Intraoperative and postoperative core temperatures in patients assigned to receive general anesthesia (n = 20) or spinal anesthesia (n = 20). All patients were actively warmed after operation. Core temperature did not differ significantly during surgery but did increase significantly faster after operation in patients given spinal anesthesia (1.2 ± 0.1°C/h *vs* 0.7 ± 0.2°C/h, means ±SDs; $P < 0.001$). Asterisks indicate significant differences between the groups ($P < 0.01$)

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proved insufficient to prevent hypothermia, and intraoperative core cooling rates were virtually identical in the patients given general and spinal anesthesia. Similar cooling rates have been observed in some previous studies[9,10] but not in others.[8,11] It seems likely that patients given regional anesthesia will remain warmer when their upper body thermoregulatory defenses remain intact. In contrast, hypothermia may be comparable when age, illness, or sedation impairs control.[5-7,22]

Thermoregulatory vasodilation associated with induction of general anesthesia alters core temperature approximately three times as much as subsequent intraoperative vasoconstriction.[1,23] Consistent with this difference, thermoregulatory vasomotor status has little[24] or no[25] influence on peripheral-to-core heat transfer during anesthesia. In contrast, peripheral-to-core heat transfer may be markedly impeded after operation.[16,17,#] These data suggest that peripheral anesthetic-induced (nonshunt) vasodilation also contributes markedly to intercompartmental heat transfer.

Previous results suggest a model in which the large core-to-peripheral flow of heat observed during induction of general anesthesia[1] results from combined inhibition of tonic thermoregulatory vasoconstriction[7,26] and peripheral anesthetic-induced vasodilation.[15] During surgery, thermoregulatory vasoconstriction is less effective because its protective effects are opposed by continued peripheral, anesthetic-induced vasodilation.[24,25] After operation, thermoregulatory vasoconstriction and the absence of peripheral anesthetic-induced vasodilation again combine, this time to restrict intercompartmental flow of heat. Consistent with this model, active warming after general anesthesia sometimes increases core temperatures no faster than passive insulation,[16,17,#] although differences of about 1°C/h would be expected based on differences in cutaneous heat transfer.[27-29] (Suitably faster rewarming with active heating has been identified in other studies.[30-32]) Major conduction anesthesia differs from general anesthesia in not dissipating rapidly at the end of surgery. Consistent with our model, postoperative core temperatures increased 70% faster in patients given spinal anesthesia.

In summary, core temperature decreases similarly in patients given spinal and general anesthesia, presumably because the combination of spinal anesthesia and meperidine administration obliterated effective peripheral and central thermoregulatory control. Residual spinal anesthesia, which maintained lower body vasodilation, significantly increased the rate of core rewarming. Vasodilation thus facilitates core rewarming in patients after operation with residual lower-body sympathetic blocks, just as it does during general anesthesia.

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