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# Inhibition of Postanesthestic Shivering with Radiant Heat

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Postanesthetic shivering (PAS) with its attendant subjective feeling of intense cold is one of the most distressing aspects of the immediate postoperative period for many patients. PAS is associated with an increase in oxygen consumption[1]; it generally adds an extra burden to the cardiopulmonary system, which may already be compromised in some patients. Indeed, myocardial infarction[2] has been linked with the marked increase in oxygen demand and the hypoxemia that occurs with PAS.[3–5] Although there is general agreement that PAS should be prevented, many contributing factors, such as low ambient temperature in the operating room, use of cold fluids for infusion, *etc.*[6,7,**] are not easy to control. Certain drugs such as methylphenidate[8] and opiates[9] have been used to stop PAS with only partial success, and injections of the amino acid taurine have inhibited PAS in monkeys,[10] but administration of additional drugs in the postoperative period may not be the best solution. In recent studies of PAS in an unoperated, anesthetized, subhuman primate model,[10] acute application of radiant heat to the skin immediately interrupted shivering even though deep body temperature remained low. Rapid changes in shivering as the heat lamp was turned on and off suggested that a similar technique might be useful in the control of PAS in humans. This effect was tested on PAS in obstetric patients in studies described in the following. Positive findings in these experiments led us to compare the effect on duration of PAS of constant radiant heat exposure with PAS duration when warm blankets were used.

## METHODS

### *Experiment 1: Acute, Repeated Applications of Radiant Heat*

*Subjects:* After the entire study protocol was approved by the Institutional Review Board, 30 female obstetric patients classified as ASA I or II who shivered postoperatively were studied. These patients had either a cesarean section or postpartum tubal ligation performed under general, spinal, or epidural anesthesia. Their average age was 25.2 ± 1.1 (SEM) yr, and their average weight was 74.1 ± 3.3 (SEM) kg. All patients were tested in the postoperative recovery area immediately after surgery.

*Anesthetic procedures:* Sodium citrate (15 ml, po) was given to the cesarean section patients, and diazepam (10 mg, po) was additionally given to the patients having tubal ligations, as preoperative medications.

Thiopental sodium (4 mg/kg) was used for induction of general anesthesia, and succinylcholine (1–1.5 mg/kg) and atracurium (0.3–0.5 mg/kg) were given for muscle relaxation. All patients received $N_2O$ and $O_2$ in a concentration of 70/30% except when administered prior to delivery when a 50/50% concentration was used. Isoflurane (22 cases) and enflurane (8 cases) were added to the basal anesthetic. Fentanyl (2–3 μg/kg, iv) and droperidol (2.5 mg iv) were given after clamping the cord in those patients having a cesarean section and at induction in all others. All of those having cesarean section received morphine 5 mg iv shortly before the end of the procedure.

The patients receiving spinal anesthesia were given 5% lidocaine in 10% dextrose (average dose 70 mg). For epi-

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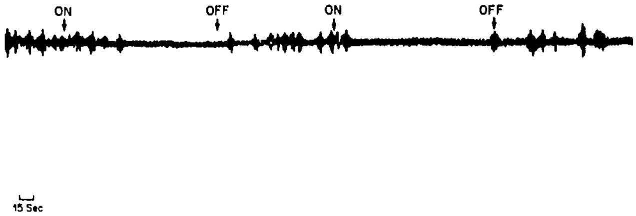


FIG. 1. Representative EMG tracing showing inhibition of shivering with application of radiant heat and recurrence when the heat was turned off.

dural anesthesia 2% lidocaine was given (average volume 22 ml). The initial 3 ml, or 10 ml, of the latter solution contained epinephrine 1:200,000. Six of those who received regional anesthesia were also given fentanyl (1.0 μg/kg iv) at some time during the procedure. The average duration of anesthesia for all surgeries combined was 84.4 ± 5.61 (SEM) min.

*Apparatus and procedure:* Sublingual temperature of all patients was recorded after arrival in the recovery room and at the end of the 10-min study period, and all were maintained in the supine position with a 10–20° head-up tilt. Lead II of the electrocardiogram was continuously monitored. Using a Grass Medical Instruments (Quincy, MA) Model 7D polygraph, a graphic recording of shivering was established, and recording was maintained for the duration of the experiment. The radiant heat source was a linear arrangement of three 250-watt infrared heat lamps centered from the upper thoracic to the suprapubic area. These lamps were attached to an overhead stand and were placed 18–24 in above the sternum of the patient. All patients were covered with one layer of lightweight bedclothes (gown or sheet) with the face and neck uncovered. Preliminary studies indicated that these conditions kept skin temperature from rising above 43° C for the duration of the exposure. In this study, heat lamps were initially turned on for 3 min and were then turned off for the next 2 min, followed by one repetition of this cycle.

### *Experiment 2. Comparison of Radiant Heat and Warm Blanket Treatment*

*Subjects:* Thirty additional obstetric and gynecologic patients classified as ASA I or II who shivered postoperatively were studied. These patients had either a cesarean section (n = 17) or tubal ligation (n = 13) performed under general, spinal, or epidural anesthesia. Each was assigned to radiant heat or warm blanket treatment according to a table of random numbers. The average age of the group who received radiant heat (RH) was 23.53 yr. ± 1.05 SEM. The average (±SEM) age of the group treated with warmed blankets (WB) was 24.13 ± 1.11 yr. The average weight of those in the RH group was 66.1 ± 3.7 kg, and in the WB group it was 69.6 ± 2.6 kg. All patients were tested in the postoperative recovery area immediately after surgery.

*Anesthetic procedures:* The anesthetic procedures were generally the same as in experiment 1.

*Apparatus and procedures:* After arrival in the recovery area sublingual temperature of each patient was recorded and all were nursed in the supine position with a 10–20° head-up tilt. The techniques for recording shivering and skin temperature were the same as in experiment 1.

The RH group was actively heated using the radiant heat lamps as before except that the heat treatment was not intermittent but continuous for up to 30+ min. A graphic recording of the presence or absence of shivering was obtained at 1, 2, and 5 min after application of heat and then at 5-min intervals. Visible shivering was observed continuously.

The patients in the WB group were treated in the standard fashion for complaint of cold, consisting of application of a prewarmed blanket over the body. A graphic recording of shivering was established at the time intervals stated in the previous paragraph. Initially, patients in this group were allowed to shiver to spontaneous cessation, up to 45 min. However, in the course of the study a time limit of 30 min was set, after which radiant heat was applied to WB patients who were still shivering. The sublingual temperature in this group was again recorded at the end of the shivering, or prior to application of radiant heat. All patients received postoperative visits within the first 24 h after surgery.

## RESULTS

### *Experiment 1*

Mean (±SEM) oral temperature at the time of entry into the recovery room was 35.6 ± 0.1° C, and all patients had clearly observable to marked shivering. The average postwarming temperature was 36.2 ± 0.1° C.

Twenty-two of these thirty patients showed rapid cessation of shivering in response to radiant heating (fig. 1). The average time from first application of heat to complete cessation of shivering was 60.6 ± 9.8 s. When the lamps were turned off these patients resumed shivering within 42.8 ± 6.9 s. Although thermal affect was not recorded systematically, when they again began to shiver many of these patients requested that heating be reapplied. When heat was reapplied, shivering again stopped completely in an average of 59.5 ± 10.2 s. Eighteen of these patients began to shiver within 49.2 ± 8.3 s when heating was again stopped. The remaining four patients in this group did not resume shivering for the duration of the study.

Four patients did not completely stop shivering during the heating periods but did show inhibition of shivering. These patients were initially shivering more vigorously

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than those who stopped shivering after heat application. There was a reduction of shivering when the heat lamps were turned on in each case (average latency 67.5 ± 32.8 s with first heating, 67.5 ± 37.8 with the second), and more vigorous shivering generally occurred when the heating was turned off (average latency to exacerbation 37.8 ± 4.3 s during the first heat-off period, 41.3 ± 14.8 during the second). The remaining four patients showed reduction or cessation of PAS on at least one treatment occasion.

*Experiment 2*

After 10 minutes of treatment, all RH patients ceased shivering, while no WB patient had stopped shivering (Mann-Whitney test, $P < 0.001$, fig. 2). Average duration (±SEM) of PAS in RH patients was 5.0 ± 0.4 min, while 67% of the WB group was still shivering at the end of the 30-min test period ($P < 0.001$, Mann-Whitney test). Mean sublingual temperatures of the RH and WB groups on entering the recovery room were virtually the same (35.5 ± 0.27° C = RH; WB = 35.9 ± 0.16° C; $P > 0.1$). The average temperature at the end of shivering was 36.8 ± 0.24° C for the RH group and 36.6 ± 0.18° C for the WB group ($P > 0.2$). Postoperative visits the day after surgery revealed no epidermal initiation or burns related to heat lamp treatment and patients recalled the radiant heating as a pleasant, salutary experience.

## Discussion

A frequent change in anesthetized patients is a reduction in body temperature. This reduction in temperature represents a "debt" that must be paid postoperatively either by endogenous production (*i.e.*, PAS) and conservation of heat and/or by adding heat *via* an exogenous source. Restoration of body heat through PAS may require up to 500% increase in metabolism.[11] While the cause of PAS may be complex, low postoperative temperature is a major factor,[10] and it was, perhaps, the primary factor in the current series of shivering patients.

In the first experiment, shivering was rapidly stopped or inhibited in nearly all cases by briefly applying heat to a relatively small part of the body surface. The inhibitory effect was obvious even in cases where shivering did not cease entirely. The latency to cessation of shivering was greater in these experiments than in those on squirrel monkeys reported earlier.[10] In the monkeys shivering stopped immediately when a heat lamp was turned on. It is noteworthy that a much greater surface area was warmed in the subhuman primates than in the patients and that the interposition of one layer of cloth in the patients undoubtedly reduced the rate of heating. The sensitivity to warmth of different regions of the body is not equal with respect to capacity to influence physiologic thermoregulatory responses and subjective appreciation

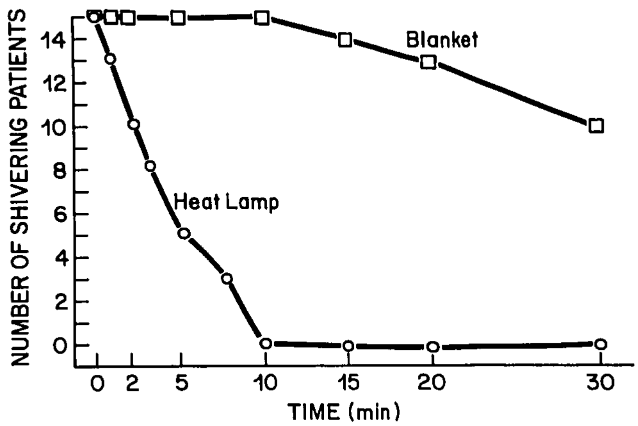


FIG. 2. Effect of radiant lamp *vs.* warmed blanket treatment on duration of PAS. Scores are numbers of patients still shivering at each time interval.

of thermal stimuli.[12,††] For example, if the face and chest are exposed to a given intensity of radiant heat, the increase in the rate of sweating on the thigh is approximately three times greater during face radiation than during chest radiation per unit of skin area irradiated and per temperature increase.[12] This evidence is consistent with data that indicate that certain regions, such as the face, have a greater sensitivity to warmth than do other skin areas.†† The evidence indicates that stimulation of the neck, chest, and abdomen should have a powerful influence on thermal sensations and physiologic responses,[12] just as we observed. It should be possible to demonstrate even greater inhibition of shivering by additionally warming the upper legs and other body regions.

Because core temperature was low in the shivering patients, why did shivering not continue until deep body sites were warm? The technique we describe for inhibiting shivering apparently takes advantage of a response noted in dogs in 1949[13] that shivering due to low core temperature was completely inhibited when skin temperature was raised above 40° C. It appears that a similar circumstance exists in humans and that it is possible to control PAS and thermal discomfort despite low core temperature by activating warmth receptors that are densely distributed in the blush region, thus altering the thermal signals reaching the nervous system and neurophysiologically inhibiting PAS.

The results of the second experiment clearly show the superiority of radiant heating over warmed blanket treatment in control of PAS. Radiant heating reduced shivering duration approximately 84% over the 30-min test period. This reduction would be larger if the cases that shivered for up to 45 min were considered.

We know of no other controlled study in which this

†† Stevens JC, Marks LE: Spatial summation and the dynamics of warmth sensation. Percept Psychophysics 9:391–398, 1971.

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method of controlling PAS was compared with other techniques. It is worth noting that the relatively inexpensive heaters we used provide more intense and localized heat than commercial over-bed units currently available. The small size of the apparatus and the localized application of heat are additional benefits to those who must work closely with the patient in the recovery room.

The findings indicate that peripheral warming without immediately increasing core temperature is a simple, inexpensive, safe, and noninvasive method for stopping or inhibiting PAS, thus obviating both its dangerous physiologic effects and the unpleasant psychologic experience of cold. The technique does not require modification of equipment, procedures, or the thermal environment of the operating room. The focus is only on those patients who specifically develop PAS rather than on treatment of all patients. Perhaps more consistent use of localized radiant heat can obviate the use of drugs (*e.g.*, meperidine, neuromuscular blocking drugs) that carry risks of drug interactions and side effects and/or the requirement for prolonged ventilatory support.

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