The Effects of Ambient Temperature on Patient Temperature during Surgery Not Involving Body Cavities

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The effects of room temperatures upon body temperatures were studied by measuring esophageal, nasopharyngeal, deltoid muscle, deltoid skin and fingertip temperatures in adults undergoing surgical operations not involving the body cavities. Patients were lightly anesthetized, paralyzed, and fully draped. Room temperatures varied from 17.5° C (63.5° F) to 23.8° C (74.8° F). Intravenous fluids and transfusions were given at room temperature. At or above a critical ambient temperature of 21° C (70° F) esophageal and nasopharyngeal temperatures of patients remained essentially stable in the normal range of 36.0°-37.5° C. Body temperatures of patients in rooms cooler than 21° C were less than 36.0° C 45 minutes postinduction of anesthesia, and progressively declined at a mean rate of 0.3 degrees C/hour in the ensuing two to three hours. The difference between the two groups was significant. (Key words: Body temperature; Operating room temperature; General anesthesia, temperature.)

The ambient temperature of the modern operating room is usually maintained below 70° F to insure the comfort of the heavily-gowned staff. Semiclosed and open anesthetic systems, which contribute to patient heat loss,* are commonly used. Often, in addition, long-lasting major operations with open body cavities are done;* and large amounts of cold blood are transfused into patients.* All these factors contribute to patient heat loss, with varying degrees of hypothermia, intraoperatively.

The importance of environmental temperature as a factor in producing hypothermia in anesthetized infants and children has been documented.†‡ However, no satisfactory evidence of the effect of ambient temperature on the body temperature of the anesthetized adult has been presented. The purpose of this study was to examine the relationship of ambient temperature to body temperature in adults under light general anesthesia, in conjunction with muscle relaxants and controlled ventilation. The study was limited to operative procedures which did not involve open body cavities, in order to minimize the surface area exposed.

Methods

Body temperature changes were measured in 17 subjects, whose ages ranged from 20 to 71 years (mean age 53 years). Premedication varied.1 Procedures included three cup arthroplasties, six femoral-popliteal saphenous vein autografts, two osteotomies, three lumbar laminectomies, one Moore prosthesis, one cervical sympathectomy, and one meniscectomy.

All patients were paralyzed with either d-tubocurarine chloride or gallamine triethiodide (Flaxedil), and the lungs ventilated with a tidal volume of 10 ml/kg ten times per minute by means of a volume-limited Ohio 300 D/O ventilator. Anesthesia was maintained with nitrous oxide 4 l/min, oxygen 2 l/min, and diethyl ether 1–3 per cent, halothane (Fluothane) 0.5–0.75 per cent, methoxyflurane (Penthrane) 0.3–0.5 per cent, or a narcotic.

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Received from the Department of Anesthesia and the Anesthesia Laboratory of the Harvard Medical School at the Massachusetts General Hospital, Boston, Massachusetts 02114. Accepted for publication October 14, 1969. Supported in part by USPHS Research Grants HE-10248 and CM-15904-02.

† All patients received a drying agent (atropine or scopolamine), together with: pentobarbital only (five patients); a narcotic only (four patients); both pentobarbital and a narcotic (five patients); a narcotic and hydroxyzine (one patient); pentobarbital and phenergan (one patient); or chloral hydrate and hydroxyzine (one patient).
Intravenous fluids were infused through blood-warmer tubing§ immersed in a water bath at room temperature. After passage through the water bath, the temperature of the infused fluid was measured with a hypodermic probe inserted in the intravenous line and attached to an electronic telemeter. Average rate of fluid infusion was 525 ml/hour (range 200–1,400 ml/hour).

Room temperature was measured with a mercury thermometer. Midesophageal, nasopharyngeal, deltoid muscle, deltoid skin and fingertip temperatures were measured with electronic thermistors and telemeters,¶ which were calibrated with a mercury thermometer by means of constant-temperature water baths. Muscle and skin thermistors were always placed on the arm opposite that receiving the intravenous fluids.

Temperature measurements were begun 45 minutes after induction of anesthesia, then recorded every 15 minutes for the duration of the procedure. Because anesthesia lasted at least two hours for each of the 17 cases studied, temperature measurements utilized in evaluating the whole-group data were those taken every 15 minutes from 45 through 120 minutes postinduction. Twelve patients underwent anesthesia for three or more hours. This subgroup was examined for changes in esophageal and nasopharyngeal temperatures at 60, 90, 120, 150, and 180 minutes after start of anesthesia, in addition to the previously-mentioned evaluation.

No measurements were made prior to induction of anesthesia, or during the interval required for induction of anesthesia and for preparing and draping the patient, since we wished to measure only the effect of room temperature on body temperature (not the effect of the foregoing preparations for surgery).

Uncorrelated Student’s t tests were used to compare the 1) mean body temperatures or 2) mean body-temperature regression coefficients of patients in rooms with temperatures above 21°C with the corresponding values for patients in rooms with temperatures below 21°C. Regression coefficients, regression lines, and the correlation between esophageal and nasopharyngeal temperatures were calculated as described by Fisher.\(^9\)

**Results**

**Esophageal and Nasopharyngeal Temperatures (Table 1)**

The relationship between individual esophageal temperatures and the corresponding room temperatures was not linear (fig. 1, top). Most patients in rooms warmer than 21°C had normal esophageal temperature of 36°C or higher, whereas all patients in rooms cooler than 21°C had esophageal temperatures below 36°C. The mean esophageal temperature of patients in warm rooms (>21°C) was 36.1°C, and that of patients in cooler rooms (<21°C) was 35.2°C. The difference between these means was significant (t = 4.005, P < 0.01).

Figure 1 (bottom) shows the relationship of regression coefficients for individual esophageal temperatures to room temperatures. Patients in rooms 21.0°C or warmer had essentially no further decreases (mean less than 0.03°C/hour) in esophageal temperature from the first value 45 minutes postinduction, whereas those in rooms cooler than 21.0°C had a further mean decrease of 0.3°C/hour (fig. 2, top). The difference between the two mean group regression coefficients was significant (t = 3.182, P < 0.01).

This difference between mean esophageal temperatures and esophageal temperature regressions in patients in warm rooms (>21.0°C) and cold rooms (<21.0°C) was also evident in the 12 subjects who were studied for three or more hours. Patients in the warmer rooms had a mean esophageal temperature of 36.2°C, which remained stable (fig. 2, bottom). On the other hand, patients in rooms cooler than 21.0°C had a mean esophageal temperature of 35.2°C, which decreased at a rate greater than 0.3°C/hour. The differences between the two groups in both mean esophageal temperatures and esophageal temperature regressions were significant (t = 3.990, P < 0.01 and t = 3.048, P < 0.02, respectively).

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§ Baxter Flextron R 66.
¶ Mercury thermometers used were Kantroll-Thermometer Ceb. Haake KC. Yellow Springs International probes #401, 402, 409, and 513 were used in conjunction with #43 TD and 41 TA telemeters.


**Table 1. Room and Body Temperature Values**

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<tr>
<th></th>
<th>Case 14</th>
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<th>Case 11</th>
<th>Case 2</th>
<th>Case 12</th>
<th>Case 16</th>
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<td>-0.0026</td>
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<td>-0.0034</td>
<td>0.0000</td>
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<tr>
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Individual nasopharyngeal temperatures were consistently equal to or slightly higher than corresponding esophageal temperatures, and there was a good correlation between mean esophageal and mean nasopharyngeal temperatures ($r = 0.9920$, $P < 0.001$). In addition, the relationship of mean nasopharyngeal temperatures and temperature regressions to room temperatures paralleled the relationships of esophageal temperatures to room temperatures (Fig. 2). The differences between mean nasopharyngeal temperature and temperature regression in patients in warm rooms (>21.0 °C) and cold rooms (<21.0 °C) were also significant.

**Deltoid Muscle Temperatures**

The difference between the mean muscle temperature of 34.4 °C in subjects in rooms warmer than 21.0 °C and that of 33.4 °C in those cooler than 21.0 °C was not significant ($t = 2.011$, $0.1 > P > 0.05$). Nor was there a significant difference between regression coefficients for muscle temperature in the two groups.
or 45 through 120 Minutes Postinduction

<table>
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<td>-0.0553</td>
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</table>

### Skin Temperatures

In contrast to the muscle temperatures, the difference between the 31.4°C mean deltoid skin temperature in warm rooms (>21.0°C) and the 29.0°C mean temperature in colder rooms (<21.0°C) was significant (t = 2.779, P < 0.02). However, there was no significant difference between deltoid skin temperature regressions in the two groups.

Fingertip temperatures were quite variable, and no significant relationships with either room temperature range or any body temperatures were found.

### Age and Anesthetic Agent

No correlation between body temperature and either patient age or the general anesthetic agent (i.e., diethyl ether, halothane, methoxyflurane, narcotic) utilized was found.

### Room and Infused-fluid Temperatures

The mean room temperature for the 17 subjects was 20.8 ± 1.9°C (SD), and the mean infused-fluid temperature was 21.0 ± 1.8°C. There was no significant difference between these means (t = 0.410, P > 0.6).

![Fig. 2. Top, regression lines of mean esophageal and nasopharyngeal temperatures of patients in rooms warmer than 21°C and cooler than 21°C 45-120 minutes after induction of anesthesia (17 subjects). Bottom, regression lines for the same values 60-180 minutes postinduction (12 subjects).](http://anesthesiology.pubs.asahq.org/pdfaccess.ashx?url=data/journals/jasa/931593/...
Discussion

Patients at temperatures of 21.2 to 23.8°C (70.2 to 74.8°F) had essentially stable esophageal and nasopharyngeal temperatures in the normal range of 36.0 to 37.5°C. In no patient in the rooms cooler than 21°C were the temperatures normal, nor did their esophageal and nasopharyngeal temperatures remain stable; instead, they consistently decreased (mean rate greater than 0.3°C/hour) for the observed two to three hours of anesthesia. The differences between the two groups in these measured temperatures and their rates of fall were significant. There was also a significant difference between the two groups in deltoid skin temperatures, but not in rate of fall of deltoid skin temperature.

A room temperature of 21.0°C (69.8°F), therefore, is the “critical ambient temperature” for the lightly-anesthetized, paralyzed, fully-drugged adult patient undergoing surgical operation which does not involve body cavities. At this and higher room temperatures metabolic heat production is large enough to offset heat loss and maintain internal body temperature at the normal 36–37.5°C. At lower environmental temperatures heat loss exceeds heat production and body temperature falls. A “critical environmental temperature” of 20°C has been demonstrated for resting, unclothed, unanesthetized adults by Wyndham and his associates. The metabolic rates of his subjects, exposed to air temperatures varying from 27 to 5°C, remained stable until the air temperature fell below 20°C, then rose sharply.

The critical temperature demonstrated under the conditions of this study is subject to other influences. Most of our patients received only moderate amounts of intravenous fluids (average rate, 500 ml/hour), warmed to room temperature. Large volumes of cold blood would have caused greater decreased body temperature. Conversely, warming the infused fluids would have decreased heat loss.

Patients with open body cavities—and consequently with large exposed surface areas—lose more heat than those undergoing more superficial procedures, and so do patients with larger surface areas relative to body mass (such as infants, the elderly, or the cachectic). In addition, patients who are lightly anesthetized have a lesser fall in temperature than those undergoing deep anesthesia, and our patients were lightly anesthetized. Therefore, we would anticipate that patients having surgical operations in which the thoracic or abdominal cavity is open, and those who are deeply anesthetized, very young or old, or are receiving large volumes of cold intravenous fluids would have higher “critical” ambient temperatures than the patients in this study.

All patients received neuromuscular blockers. Could the use of these drugs have decreased their heat production significantly, and caused the demonstrated “critical ambient temperature” of 21°C to be higher than anticipated for spontaneously-ventilating, anesthetized adults? This seems unlikely since Smith was unable to find significant differences between reductions of esophageal and muscle temperatures among paralyzed and spontaneously-ventilating patients undergoing light general anesthesia.

Mild hypothermia during surgical operation has not been demonstrated to be either beneficial or harmful. However, postoperative shivering may result in circulatory stress, reported in both children and adults. The relationship between intraoperative hypothermia and postoperative shivering has been studied by Roe et al., who found that falls of 0.3 to 1.2°C in rectal temperature during anesthesia and operation were followed by an average increase of 92 per cent in oxygen consumption postoperatively (compared with preoperative oxygen consumption). In addition, Hammel et al. found that a fall of less than 1°C in hypothalamic temperature resulted in a fourfold increase in body heat production when unanesthetized rhesus monkeys were in a “cool” environment of 20–24°C.
Thus, it is possible that any patient whose esophageal temperature falls below 36°C during surgical operation may shiver postoperatively.

Warming blankets and warming infused fluids may help decrease patient heat loss.4,12 However, these maneuvers are not as reliable, as efficient, or as simple as maintaining the patient’s environment at a temperature higher than 21°C, which has been found to be the “critical ambient temperature” for minimizing intraoperative heat loss under the conditions of this study. Clark et al. have shown that above an ambient wet-bulb temperature of 23.9°C there is a danger of heat retention and hyperpyrexia. Hence, we recommend maintaining operating room temperatures between 21.0 and 23.9°C (70–75°F), as well as monitoring the esophageal or nasopharyngeal temperature of every patient undergoing a major surgical operation.

References


