After our experience with this system and the preparation of this report, we found that Johnson and Ito [2] had reported a system using small oxygen tanks for a pressure source in 1969. However, tanks have to be replaced, and their pressure watched. Using the regulator with piped gas is simpler, requires less attention, and is less expensive.

REFERENCES

1. Gardner RM, Warner HR, Toronto AF, et al: Catheter-flush system for continuous monitoring of central arterial pulse waveform. J Appl Physiol 29:911–913, 1970
2. Johnson DG, Ito T: Continuous flush of arterial pressure-recording catheters. J Thorac Cardiovasc Surg 57:675–678, 1969

The Effect of Warming Blankets on Maintenance of Body Temperature of the Anesthetized, Paralyzed Adult Patient

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Surgical patients frequently become hypothermic (body temperature less than 36 C) during operation. Thermal blankets have been recommended for preventing intraoperative heat loss,[1–5] but their usefulness and safety have been questioned.[6–8] Maintenance of ambient temperatures in the range of 21–24 C has also been recommended as a means of decreasing intraoperative heat loss.[3, 9, 10] This study was undertaken to determine the effectiveness of warming blankets, as used clinically, in preventing hypothermia, compared with the effect of operating room temperatures.

METHODS

Fifty adult patients undergoing either intra-abdominal surgery or procedures not involving any body cavity were studied. A warming blanket covered by two thin layers of cotton blanket was placed beneath each patient in the study group. Thermal blankets were attached to previously warmed blanket-heating units (selected temperature 41 C) before induction of anesthesia. Anesthesia was induced in the operating room with thiopental sodium (Pentothal), followed by succinylcholine hydrochloride (Anectine) for intubation. Maintenance was accomplished with nitrous oxide, 3–4 l/min, and oxygen, 2 l/min, supplemented by an intravenously-injected narcotic (alone or in combination with a tranquilizer).‡ A nondepolarizing muscle relaxant ‡ was given, and ventilation was controlled. All intravenous fluids were infused at room temperature.

Temperatures measured with either mercury thermometers or calibrated thermistors and telethermometers were: 1) preoperative oral; 2) warming-unit fluid; 3) upper surface of the cotton blanket covering the thermal blanket; 4) esophageal (38 cm from the incisors); 5) operating room.

Patients in cold (18–21 C) rooms have been shown to have significantly greater decreases in esophageal temperature than those in warm (21–24 C) rooms.[9, 10] Therefore, in order to compare the efficacy of warming blankets in preventing hypothermia with the effect of room temperature, the patients were grouped as follows: I. ten study patients versus 17 con-

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‡ Choices of narcotic (morphine, meperidine, or fentanyl), tranquilizer (diazepam, droperidol, or none), and muscle relaxant (*d*-tubocurarine or gallamine) were those of the individual administering anesthesia (not of the authors conducting the study) and hence were uncontrolled.

trol patients § in cold rooms; II. eleven study patients versus 12 control patients in warm rooms; III. ten study patients in cold rooms versus 11 study patients in warm rooms. Differences between mean esophageal temperatures of subjects in these groups after one, two and three hours of anesthesia were analyzed for statistical significance. Other variables which may affect patient temperature loss were also examined: preoperative oral temperatures; operating room temperatures; patients' ages; volume and rate of intravenous fluid infusion; operative sites (intra-abdominal versus procedures not involving a body cavity). Both standard deviations and t values for the difference between two means were calculated as described by Fisher.[11]

Results

Blanket Heating Units. Mean water temperature before starting the heating units was 21.5 ± 0.6 C. During the first 11 minutes of heating, mean water temperature rose to 41.3 ± 0.5 C. Subsequent temperatures remained stable at 40.3 C.

Blanket Temperatures. Mean changes in surface temperatures after attachment to the previously-warmed blanket-heating units are shown in figure 1. Mean surface temperature of the cotton blankets remained stable after 45 minutes of warming.

Preoperative Oral Temperatures. Mean preoperative temperature of control patients was 36.9 ± 0.2 C, and that of the warmed subjects was 36.8 ± 0.4 C. There was no significant difference between these preoperative temperatures.

Temperatures of Study and Control Groups in Cold Rooms. Mean temperatures of cold operating rooms were 19.7 ± 0.9 C for the study group and 19.7 ± 0.7 C for the control group. Mean esophageal temperatures of study and control patients are shown in figure 2. No statistically significant differences between the mean esophageal temperature of the two groups were found after one, two or three hours of anesthesia.

§ Randomization was done by drawing a number from a box containing the numbers one to 100. Odd-numbered patients were placed on warming blankets; even-numbered patients were controls.

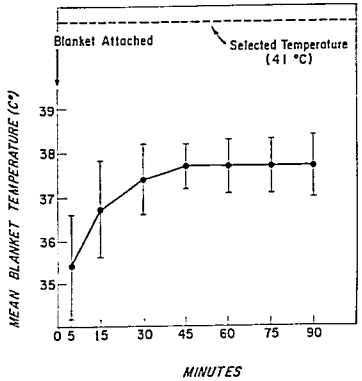

Fig. 1. Changes in surface temperature (mean ±SD) of cotton blankets covering the thermal blankets after attachment to the prewarmed heating units.

Temperatures of Study and Control Groups in Warm Rooms. Mean temperatures of warm operating rooms were 22.3 ± 0.8 C for the study group and 22.4 ± 1.0 C for the control group. Mean esophageal temperatures of study and control patients are illustrated in figure 3. Again, there were no statistically significant differences between the mean esophageal temperatures of the two groups after one, two or three hours of anesthesia.

Temperatures of Study Group in Cold and Warm Rooms. Mean esophageal temperatures of study patients in 18–21-C and 21–24-C rooms are shown in figure 4. The two- and three-hour differences of 0.6 and 0.7 C between mean esophageal temperatures of study patients in cold and warm rooms were statistically significant ($t = 2.529$, $P < 0.05$, and $t = 3.356$, $P < 0.01$, respectively).

Study Versus Control Ages, Fluid Infusions and Operative Sites. Mean age of study patients was 50 ± 22 years; that of the control group was 51 ± 18 years. Mean fluid infusion rate for the study subjects was 490 ± 180 ml/hour; that for controls was 430 ± 160 ml/hour. Seventy-six per cent of the operations in the study group and 83 per cent in the control group were intra-abdominal. In both

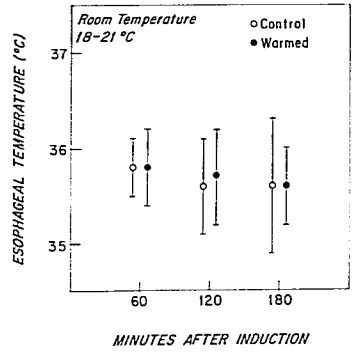

FIG. 2. Comparison of warmed patients' esophageal temperatures (mean ±SD) with those of controls in 18–21 C operating rooms. Time in minutes after induction of anesthesia.

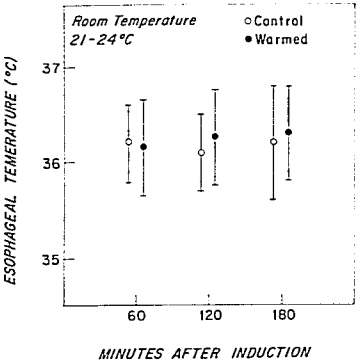

FIG. 3. Comparison of warmed patients' esophageal temperatures (mean ±SD) with those of controls in 21–24 C operating rooms. Time in minutes after induction of anesthesia.

groups the intra-abdominal operations consisted of cholecystectomies, gastrectomies and bowel resections. Other procedures in both groups did not involve a body cavity. Patients who lost more than 1,000 ml of blood during the first three hours of anesthesia were

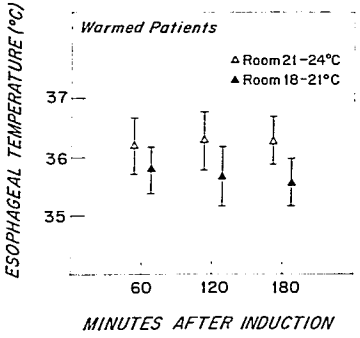

FIG. 4. Comparison of esophageal temperatures (mean ±SD) of patients on warming blankets in 18–21-C rooms with temperatures of warmed patients in 21–24-C rooms. Time in minutes after induction of anesthesia.

not included in this study. There were no statistically significant differences between study and control groups in age, rate of fluid infusion, or operative site.

DISCUSSION

The principal finding of this study is that a single warming blanket covered by two layers of thin cotton blanket is not effective in preventing hypothermia in lightly-anesthetized, paralyzed adults in cold operating rooms. Both study and control patients became hypothermic after an hour of anesthesia in 18–21-C rooms and remained hypothermic for the duration of anesthesia. In contrast, patients in both groups in 21–24-C rooms remained in the normothermic range (above 36 C) for the duration of anesthesia. The importance of the ambient temperature as a cause of patient heat loss was demonstrated by the statistically significant differences between mean esophageal temperatures of patients on warming blankets in cold rooms and warmed patients in warm rooms. No significant differences between study and control patients with regard to age, rate of fluid infusion, or operative site were found.

Several factors may have contributed to the ineffectiveness of the thermal blanket. The maximum mean surface temperature of the cotton blankets (37.7 ± 0.5 C) was only 3–5 C higher than normal skin temperature (33–35 C[12]). Since only 30 per cent of a patient's body surface area (estimated from the "Rule of Nines"[12]) was in contact with the warmed cotton blanket, the greater portion remained exposed to ambient temperature. Covering the thermal blanket with two thin layers of cotton blanket (a common practice when utilizing a warming blanket), may have resulted in a more-slowly-achieved, lower maximum temperature directly under the patient than would have resulted if such insulation had not been used. It is also possible that the cutaneous vessels of the dependent parts of the body were compressed by the weight of the patient, decreasing heat exchange between patient and blanket and also between the patient's skin and body core.

In summary, a single warming blanket covered by two thin layers of cotton blanket under a lightly-anesthetized, paralyzed adult was not effective in preventing intraoperative hypothermia, and placing a patient on a warming blanket is not a suitable substitute for adequate heating (21–24 C) of the operating room to maintain a patient in the normothermic range of 36–37.5 C.

References

1. Farman JV: Heat loss in infants undergoing surgery in air-conditioned theatres. Br J Anaesth 34:543, 1962
2. Hamblen RA, Stephen CR: Body temperature variations during anesthesia. Clin Anesth 3:189, 1968
3. Leigh MD, Belton MK: Pediatric Anesthesiology. New York, The Macmillan Company, 1960, p 433
4. Stephen CR, Dent SJ, Hall KD, et al: Body temperature regulation during anesthesia in infants and children. JAMA 174:1579, 1960
5. Newman BJ: Control of accidental hypothermia. Anaesthesia 26:177, 1971
6. Rashad KF, Benson DW: Role of humidity in prevention of hypothermia in infants and children. Anesth Analg (Cleve) 46:712, 1967
7. Smith RM: Thermic emergencies in anesthesia. Hosp Pract April 1968, pp 68–76
8. Scott SM: Thermal blanket injury in the operating room. Arch Surg 94:181, 1967
9. Morris RH, Wilkey BR: The effects of ambient temperature on patient temperature during surgery not involving body cavities. ANESTHESIOLOGY 32:102, 1970
10. Morris RH: Influence of ambient temperature on patient temperature during intra-abdominal surgery. Ann Surg 173:230, 1971
11. Fisher A: Statistical Methods for Research Workers. Twelfth edition. London, Oliver and Boyd Ltd., 1954, pp 43–52, 122–128
12. Hardy JD: Physiology of temperature regulation. Physiol Rev 41:521, 1961
13. Warren R: Surgery. Philadelphia and London, W. B. Saunders Company, 1963, p 205

(Continued from page 404)

globulin, 22.6 per cent developed hepatitis, while of 47 who did not receive gamma-globulin, 19.1 per cent had evidence of hepatitis. In the gamma-globulin-treated group, the calculated ratio was one case of hepatitis for every 19 units of blood administered, while in the non-gamma-globulin group it was one for every 17 units of blood given. The incidence of icteric hepatitis among gamma-globulin recipients was 5.5 per cent, against 8.5 per cent in those who did not receive it. This was not statistically significant. There were no deaths among the patients who developed hepatitis. Administration of gamma-globulin does not appear to be a useful therapeutic modality in the prevention of posttransfusion hepatitis. (*Spellberg, M. A., and Berman, P. M.: The Incidence of Posttransfusion Hepatitis and the Lack of Efficacy of Gamma Globulin in Its Prevention, Amer. J. Gast. 55: 564–574, 1971.*)