Heat retention using passive systems during anaesthesia: comparison of two plastic wraps, one with reflective properties†

S. DEACOCK AND A. HOLDcroft

Summary

Hypothermia during prolonged surgery may be prevented by active and passive warming methods. We have compared randomly two types of occlusive body wraps in groups of 20 patients. One wrap had additional reflective properties which, by reducing radiative in addition to convective and evaporative heat loss, was expected to improve heat conservation. Patients were studied during hepatopancreatobiliary surgery and both groups were similar in characteristics. Skin and core body temperatures increased and core temperature exceeded 37°C in 40% of patients in both groups. This continuous increase in temperature was unexpected and the observed heat gain may have been stimulated endogenously by the type of surgery rather than that supplied externally. Overall, mean hourly heat gain was similar in both groups: 71 (SD 28) kJ h⁻¹ in the reflective group and 67 (33) kJ h⁻¹ in the other group. (Br. J. Anaesth. 1997; 79: 766–769).

Key words


Core body temperature in conscious humans is regulated precisely by an intrinsic system with central hypothalamic control and a behavioural system which allows extremes of temperature to be tolerated without hypothermia or hyperthermia developing. Heat is tolerated less than cold because denaturation of proteins occurs at core body temperatures greater than 42°C whereas a similar decrease in body temperature usually causes reversible changes. Anaesthesia and surgery prevent behavioural responses and alter the homeostatic response to temperature variations by changes in both the cardiovascular effector system and central and peripheral nervous system control.¹ Perioperative core body temperatures therefore often decrease below normal. This iatrogenic hypothermia is associated with numerous postoperative complications of which the most important are shivering, which induces hypoxaemia,² and prolongation of drug action.³ These problems are more common during prolonged surgery, especially when major blood loss occurs and patients are malnourished. In severely ill patients, additional hazards of hypothermia include impaired coagulation⁴ and negative postoperative nitrogen balance.⁵

Although the hypothermic effects of anaesthesia on temperature homeostasis may be unavoidable, the physical factors which contribute to heat loss and gain may be controlled. Many different active and passive systems provide heat gain and also prevent heat loss. Body cavity exposure during surgery with resultant evaporative heat loss may not be controllable, but it is possible with access to the body for heat transfer by conduction, convection and radiation. Radiation is considered to be the major source of heat loss in an awake, resting individual. It becomes a significant factor for heat loss during surgery if the patient is uncovered in cold surroundings or is vasodilated.⁶ Radiative heat losses can be restricted by the use of metallized plastic foil, such as space blankets, but the increased risk of burns and electric shock has limited their use in the operating theatre, except for specially designed plastic wraps with punctate metal fragments on a plastic backing which do not conduct electricity (Thermadrape; Vital Signs, Sussex, UK).

It was hypothesized that the combination of plastic wraps incorporating a reflective surface to prevent radiative heat loss should provide more heat retention than a simple plastic bag during major surgery. Reflective wraps in volunteers not undergoing surgery or anaesthesia provided better insulation than plastic bags,⁷ but reflective blankets during surgery required a large surface area to be covered in order to significantly increase core temperature.⁸ It was considered that for ethical reasons relating to the complications of inducing mild hypothermia, unnecessary heat loss should be prevented in this study. Therefore, reflective and ordinary plastic bags were used with standardized heat retentive procedures. Such procedures were known to reduce but not prevent heat loss during major surgery.

S. DEACOCK*, MB BS, DA, FRCA, A. HOLDcroft, MB CHB, MD, FRCA, Department of Anaesthesia, Royal Postgraduate Medical School and Hammersmith Hospital, Du Cane Road, London W12 0HS. Accepted for publication: July 18, 1997.

*Present address: Department of Anaesthesia, Royal Hampshire County Hospital, Romsey Road, Winchester, Hampshire SO22 5DG.

Correspondence to A. H.

Patients and methods

After obtaining Ethics Committee approval and informed verbal consent, we studied 40 patients undergoing hepatopancreatobiliary surgery. Patients were allocated by random number tables before the study to one of two groups: in one group the Thermadrape wrap was used and in the other, large, thin transparent plastic bags were used. These wraps covered all limbs, except for i.v. sites. Before anaesthesia all patients were normothermic, and antibiotics were administered routinely for prophylaxis when anaesthesia commenced. The anaesthetic technique was standardized using thiopentone, fentanyl and vecuronium in appropriate doses. After tracheal intubation, anaesthesia was maintained with intermittent positive pressure ventilation of the lungs via a heat and moisture exchanger (Pall) using isoflurane and nitrous oxide in oxygen. Additional analgesia was provided with fentanyl 1 μg kg⁻¹ h⁻¹ either i.v. or combined with 0.1% bupivacaine and administered extradurally, as indicated clinically. Blood replacement during surgery was given to prevent hypotension and to maintain a packed cell volume of 30–35%. Whole or plasma-reduced blood and albumin solution (4.5% HAS) were infused on a volume replacement basis. The main replacement solution was crystalloidal, and Haemaccel was administered as indicated. Urine output was measured every 30 min.

Patients were transferred to theatre from the anaesthetic room, after insertion of invasive monitors for measurement of arterial and venous blood pressures. Active conduction of heat was standardized: a warm air mattress at 39.5 °C was positioned under the patient, fluids were warmed to 36 °C and the ambient theatre temperature was maintained at 21–24 °C. Before surgery the temperature monitors and limb wraps were positioned. Core temperature was measured in the nasopharynx. Four skin temperatures were recorded from the nipple, temperature was measured in the nasopharynx. Four monitors and limb wraps were positioned. Core temperature was measured from core thermometers (Ellab Instruments, Copenhagen). The instrument used was an Ellab PD85U digital thermometer. The normality of residuals from the ANOVA was checked using the Watson test, and Bartlett’s test was used to test the equal variance assumption. In the two patients in each group, core body temperature increased to greater than 37.5 °C during surgery. At this time active heating was discontinued and data after this intervention were not included in the statistical analysis.

Results

The two groups were similar in age, body mass index (kg m⁻²) and duration of operation (table 1). Patient age, height, weight or body mass index did not correlate with the rate of heat gain. Three patients in the Thermadrape group and two in the plastic bag group received extradural infusions. Mean blood loss measured on swabs was 1620 (range 720–13674) ml in the Thermadrape group and 1786 (571–3893) ml in the plastic group.

Mean core temperatures before surgery were 35.8 and 35.8 °C, which increased to 37.3 and 37.2 °C in those patients studied after 7 h of surgery (an increase of 1.5 and 1.4 °C) in the Thermadrape and plastic groups, respectively. Individual core temperatures indicated that 40% of patients in both groups exceeded a value of 37 °C during surgery. Figure 1 shows mean hourly measurements of core body temperature. As the mean duration of surgery was approximately 5 h, confidence intervals became wider after this time.

Mean heat gain was 71 (sd 28) kJ h⁻¹ and 67 (33) kJ h⁻¹ in the Thermadrape and plastic bag groups,

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patients characteristics and duration of operation in the two groups of patients, one wrapped in Thermadrape and the other in plastic bags (mean (sd or range))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thermadrape</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>52 (28–71)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>72 (11)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.7 (0.8)</td>
</tr>
<tr>
<td>BMI (kg m⁻²)</td>
<td>25 (3.8)</td>
</tr>
<tr>
<td>Duration of operation (min)</td>
<td>311 (122)</td>
</tr>
</tbody>
</table>

Figure 1 Relationship between core body temperature and duration of surgery for the Thermadrape and plastic bag groups, with hourly values of temperature measured as mean (95% confidence intervals). The number of patients in each group per hour is shown for each full hour of surgery.
which effector responses for heat gain and loss are nervous system response to deviations from normal temperature regulation, and in addition may blunt the cardiovascular effector control systems of temperature sequestering metabolic heat in the core thermal plateau as a result of thermoregulatory vasoconstriction. General anaesthesia may alter core temperature has been observed to exceed normal production. After approximately 3–4 h of decrease in core temperature resulting from heat loss occurs from the warm core to the cooler peripheral compartments. We expected that hypothermia would be prevented in one of the groups, but instead uninterrupted heat gain was observed in both groups. On induction of anaesthesia, redistribution of body heat normally occurs from the warm core to the cooler peripheral tissues which is followed by a slow, almost linear, decrease in core temperature resulting from heat loss exceeding production. After approximately 3–4 h of anaesthesia, core temperature has been observed to plateau as a result of thermoregulatory vasoconstriction sequestering metabolic heat in the core thermal compartment. General anaesthesia may alter cardiovascular effector control systems of temperature regulation, and in addition may blunt the nervous system response to deviations from normal body temperatures. Widening of the set points at which effector responses for heat gain and loss are generated has been described in patients not undergoing surgery. In effect, this implies that a higher or lower temperature must be reached in order to switch on the respective regulatory response.

No patient was pyrexial before surgery and patients with treated infections were not recruited. This study was undertaken in patients who had major upper abdominal surgery, some of whom had biliary stents with the potential to act as a nidus for infection and the development of septicaemia. Surgery itself induced major haemorrhage but even with blood warmers set at 36 °C this would not have increased body temperature above normal. Another contributing factor to the universal heat gain could have been the thermogenic effects of infused fluids such as albumin solution but it was considered that the amounts used as replacement for blood loss would be inadequate to provide the additional heat generated.

The inclusion of five of 40 patients with extradural infusions requires comment because extradural anaesthesia with segmental block is known to induce peripheral vasodilatation with associated heat loss during surgery or in volunteers. However, a low-dose bupivacaine extradural infusion was used in combination with an opioid for analgesia and a dense segmental block was not achieved. If any effect on body heat was expected, it should have reduced the heat gain observed.

The physical size of the patient did not correlate with the rate of heat gain. This finding did not confirm those in volunteers using insulated drapes whereby the amount of skin covered was an important factor. It was expected that patients with a large surface area related to the limbs would have a different rate of heat flux than those with small limbs, particularly as the wraps were applied in these areas. Body weight, height and body mass index showed no relationship with heat gain.

If heat loss occurs mainly by radiation during anaesthesia and surgery, then the reflective wraps should have prevented major heat loss and this group should have gained heat faster. As this did not occur, radiation as a source of heat loss during surgery may not be a major factor. However, after 3 h of surgery the increase in body heat varied between the plastic and reflective wraps. This could indicate a different response to heat dissipation between the two groups and may account for the comfort felt when wearing the reflective wrap. The relative humidity inside both wraps reached 100% within minutes and hence both wraps effectively prevented evaporative heat loss. The reflective wraps also contained a cotton lining and were produced originally as a comfortable garment to wear. This additional absorptive quality of the reflective wrap may have assisted thermoregulatory evaporation to proceed when body temperature exceeded normal limits.

It was disturbing to observe an increase in core body temperature above normal in both groups as additional methods of active heat transfer could have been used clinically in addition to the ones chosen. Core temperature measurement is usually the only site of body temperature measurement during

**Figure 2** Relationship between cumulative increase in body heat (i.e. difference between heat stored in the patient before surgery and body heat calculated hourly) and time with the two wraps. It appears from figure 2 that heat gain was similar for the first 3 h but then twice as much heat was gained in the next 2 h in the Thermadrape group. This relationship then changed so that patients in plastic wraps gained more than twice as much body heat as in the other group. However, the number of patients studied after 5 h became too few to allow statistical comparison. There were no differences in relative humidity within the wraps during the study; the internal environment inside all wraps reached full saturation within minutes and this was maintained throughout surgery.

**Discussion**

We expected that hypothermia would be prevented in one of the groups, but instead uninterrupted heat gain was observed in both groups. On induction of anaesthesia, redistribution of body heat normally occurs from the warm core to the cooler peripheral tissues which is followed by a slow, almost linear, decrease in core temperature resulting from heat loss exceeding production. After approximately 3–4 h of anaesthesia, core temperature has been observed to plateau as a result of thermoregulatory vasoconstriction sequestering metabolic heat in the core thermal compartment. General anaesthesia may alter cardiovascular effector control systems of temperature regulation, and in addition may blunt the nervous system response to deviations from normal body temperatures. Widening of the set points at which effector responses for heat gain and loss are generated has been described in patients not undergoing surgery. In effect, this implies that a higher or lower temperature must be reached in order to switch on the respective regulatory response.

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clinical anaesthesia. However, an increase in total body heat cannot be assumed unless peripheral temperatures are also increased, because in major surgery vasoconstriction may occur with a reduction in blood flow to the skin such that body heat is diverted from the periphery to the centre. The result is that total body heat can decrease while core temperature increases. This may accompany haemorrhagic shock, but was not observed during this study despite major haemorrhage.

Both systems of wraps for heat retention during surgery were effective in preventing heat loss when combined with routinely used methods. An increase in heat gain above heat loss was recorded in all patients during prolonged surgery. This emphasizes the importance of temperature monitoring when active and passive warming measures are used.

Acknowledgements

We thank Mrs D. Ridout for statistical assistance.

References