REDUCTION OF HEAT LOSS IN NEUROSURGICAL PATIENTS USING METALLIZED PLASTIC SHEETING

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SUMMARY

Metallized plastic sheeting (m.p.s.) was used in 14 neurosurgical patients and changes in body heat content during surgery compared with those of 14 control patients. All patients, except three in the study group and one in the control group, lost heat by the end of the operation. There was, however, a statistically significant reduction in heat loss in the patients wrapped in m.p.s. Measurement of skin temperature offers an important contribution to management of heat balance during anaesthesia.

It is well recognized that heat losses frequently occur in patients during anaesthesia and surgery. This may be because of relatively low ambient temperature, administration of cold i.v. fluids, use of unhumidified gases, evaporation from body cavities, metabolic depression by drugs and loss of muscle activity. The resulting hypothermia can produce physiological disturbances during the recovery period (Vale and Lunn, 1969), when the heat loss is regained by a combination of shivering and vasoconstriction (Hall, 1978). Oxygen consumption has been shown to increase by up to 486% (Bay, Nunn and Prys-Roberts, 1968). There may also be marked cardiovascular instability, in particular acute arterial hypertension (Holdcroft, 1980).

Metallized plastic sheeting (m.p.s.) acts by reducing heat loss from radiation, but also reduces convective losses by excluding draughts. The use of m.p.s. in neurosurgical patients has been studied by Radford and Thurlow (1979). They compared core (oesophageal) temperatures of insulated and uninsulated patients and concluded that, in this respect, m.p.s. had no advantage over the use of a cotton blanket alone. In our neurosurgical unit it has been normal practice to wrap patients in m.p.s., since we had developed the clinical impression that m.p.s. reduced the problems of hypothermia in the recovery period. We therefore repeated the study examining heat balance rather than core temperature alone.

**Measurement of changes in body heat content**

The relative contributions to mean body temperature $\bar{T}$, from core and mean skin temperature were derived by Burton (1935) as:

$$\bar{T} = 0.66 T_c + 0.34 \bar{T}_s$$

where $T_c$ = core temperature and $\bar{T}_s$ = mean skin temperature ($^\circ$C).

Changes in heat content, $\Delta H$, can then be calculated, in kilojoules, as shown:

$$\Delta H = \text{sp.ht.} \times M \times \Delta \bar{T}$$

where sp.ht. = specific heat of body tissues (3.47 kJ kg$^{-1}$°C$^{-1}$), $M$ = body weight (kg), $\Delta \bar{T}$ = change in mean body temperature.

**Mean skin temperature**

Mean skin temperature is the average temperature of the skin over the whole body and cannot be measured precisely. The techniques of measuring mean skin temperature ($T_{sk}$) have been evaluated by Shanks (1975), who concluded that preferably at least 10 skin sites should be used for an unweighted mean or, when access was limited, a reasonable approximation can be obtained by the four-point technique of Ramanathan (1964):

$$T_{sk} = 0.3 \text{ (nipple + arm)} + 0.2 \text{ (thigh + calf)}$$

Because of surgical requirements our choice of sites was restricted. We used the four-points recommended by Ramanathan and an additional six sites.
were selected as shown in fig. 1, in order to obtain an unweighted mean of 10 sites.

FIG. 1. Sites of temperature sampling.

METHOD
Twenty-eight patients, aged 24–74 yr, undergoing elective craniotomy in the supine position were allocated to either the study group (insulated with m.p.s.) or the control group (no m.p.s.). Patients with pyrexia before operation, or alteration in level of consciousness, were excluded.

All patients wore a cotton theatre gown and antiembolism stockings and were covered with one cotton blanket. On arrival in the anaesthetic room the 14 study patients were additionally covered with a heavyweight "Space Blanket" (Thermos) and before moving into theatre this was tucked under the patient so as to enclose all except the head and shoulders and the distal parts of the arm cannulated for i.v. infusion.

Premedication with oral lorazepam or diazepam was given 2 h before induction. Anaesthesia was induced with thiopentone and suxamethonium and, after tracheal intubation, controlled ventilation was established using nitrous oxide and oxygen. This was supplemented by an infusion of Althesin and fentanyl, or by increments of pethidine, and some patients received 0.5% halothane. Neuromuscular blockade was maintained using alcuronium or tubocuraine, and if required hypotension was induced using an infusion of sodium nitroprusside.

At induction, venous and arterial cannulae were introduced and the arterial pressure, e.g. and end-tidal carbon dioxide concentration subsequently monitored. The last value was maintained at 3–4%. I.v. fluids were given at room temperature and any blood transfusion required was administered through a blood warmer. All patients had intra-operative intermittent calf compression with inflatable leggings. After induction of anaesthesia an oesophageal thermistor probe was inserted until it was judged to lie at the nipple line and a rectal thermistor was introduced. The skin thermistors were taped in place, thermistors 3, 4 and 5 being on the arm opposite to the i.v. infusion.

Temperature measurements were made using a specially designed 12-channel electro-thermometer (Telemechanics). The thermistors were compared with mercury-in-glass thermometers over the range 25–40°C and were shown to correspond to within ±0.1°C. Theatre temperatures were measured to within ±0.1°C at the beginning and end of surgery. Relative humidity was constant at 50%. Temperature recordings were made just before entering theatre and at 30-min intervals until the end of surgery. Changes in heat content were calculated, in kJ, for each 30-min interval. Statistical analysis of the data was confined to the first 3.5 h of surgery because of insufficient patient numbers beyond this interval.

RESULTS
The comparability of the control and study group was examined, and the frequency of possible variables tabulated (table I). The two groups were similar with respect to sex, age, weight, duration of surgery, initial rectal temperature and theatre temperatures. The control group had a greater frequency of aneurysm surgery and use of sodium nitroprusside and a smaller frequency of halothane use.

Mean rectal temperatures for the two groups are shown in figure 2. There was no significant difference between the two groups (Student's t test), but a progressive and significant reduction within each group with time. Oesophageal temperatures were similarly examined and gave similar results, thus confirming the findings of Radford and Thurlow (1979).

The mean changes in heat content from the initial observation for the two groups of patients are shown in figure 3, using the four-point technique for deriving $T_{	ext{a}}$. At 60 min and each 30-min interval subsequently, there was a highly significant difference between groups ($P<0.01$). Using the 10-point sys-
TABLE I. Comparison of study and control groups

<table>
<thead>
<tr>
<th>Measure</th>
<th>M.p.s. group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of males (%)</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Age (yr) (mean ± SD)</td>
<td>52.6 ± 13.5</td>
<td>47.8 ± 11.2</td>
</tr>
<tr>
<td>Body weight (kg) (mean ± SD)</td>
<td>69.2 ± 13.4</td>
<td>62.3 ± 11.5</td>
</tr>
<tr>
<td>Duration of operation (h) (mean ± SD)</td>
<td>4.18 ± 0.98</td>
<td>3.84 ± 1.02</td>
</tr>
<tr>
<td>Proportion of aneurysm surgery (%)</td>
<td>50</td>
<td>79</td>
</tr>
<tr>
<td>Drugs used (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halothane</td>
<td>35.7</td>
<td>21.4</td>
</tr>
<tr>
<td>Nitroprusside</td>
<td>35.7</td>
<td>42.9</td>
</tr>
<tr>
<td>Initial rectal temperature (°C) (mean ± SD)</td>
<td>36.9 ± 0.6</td>
<td>36.8 ± 0.4</td>
</tr>
<tr>
<td>Theatre temperature (°C) (mean ± SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>22.7 ± 0.7</td>
<td>22.7 ± 0.8</td>
</tr>
<tr>
<td>Finish</td>
<td>22.7 ± 0.52</td>
<td>22.8 ± 1.2</td>
</tr>
</tbody>
</table>

During the 3.5-h period studied, we have shown that there was no significant difference between the two groups in either rectal or oesophageal temperatures. This confirms the findings of Radford and Thurlow (1979). However by examining, in addition, changes in heat content we have shown that m.p.s. is of value in reducing heat loss during long neurosurgical operations.

In 1935 Burton calculated that 50% of the body mass lies within 2.5 cm of the skin surface, thus
highlighting the importance of inclusion of skin temperature in estimating mean body temperature, and hence changes in body heat content. Of the patients in the study group, three of 14 had no loss of heat during anaesthesia, despite having significant decreases in rectal temperature. One of the 14 control patients had no significant decrease in heat content and was atypical in that he showed an increase in rectal temperature from start to finish during surgery.

We used rectal temperature measurements for core temperature in our calculations as suggested by Burton (1935). Although changes in rectal temperature lag behind oesophageal temperatures, we believe the time intervals between observations to be sufficient for this to be unimportant. Oesophageal probes are also more difficult to position accurately at the desired level in the lower quarter of the oesophagus (Whitby and Dunkin, 1968). At higher levels in the oesophagus large variations can occur because of the proximity of the trachea and the pulmonary veins.

It might be expected that choice of anaesthetic agent and theatre temperature could influence patient heat balance. Morris (1971) has shown that the choice of anaesthetic agent does not significantly influence the patient's body temperature. He has also examined the effect of ambient temperature and showed that theatre temperatures of 24–26 °C were required to prevent hypothermia in uninsulated patients. These values may be uncomfortably warm for the theatre personnel and, in our study, theatre temperatures were between 21 and 24 °C.

Holdcroft and Hall (1978) have also demonstrated that at a constant theatre temperature of 24 °C, body temperature changes were unrelated to either the type of anaesthesia or the percentage of subcutaneous fat to body weight.

Estimation of mean skin temperature during anaesthesia presents problems. While its measurement has been assessed in patients covered with surgical drapes (Shanks, 1975) no comparable studies have been carried out in patients wrapped in m.p.s. A critical evaluation of the methods for estimating mean skin temperature in insulated patients is outwith the scope or intent of this present study.

Since the head, shoulders and distal part of one arm were uninsulated, our study patients would be subject to different cooling influences in the theatre. However, we thought it probable that the effect of these differences would be small. We also used two different methods of estimating mean skin temperature. The four-point "weighted" method of Ramanathan involved four sites, all within the m.p.s. cocoon, while the "unweighted" mean of 10 skin sites included one point outside the m.p.s. covering. The four-point method has been shown to give results to within 0.2 °C of the 15-point formula of Winslow (Holdcroft and Hall, 1978). Our data show that both methods resulted in a significant reduction in heat loss in the m.p.s. group.

While we have shown that the use of m.p.s. does reduce heat loss during surgery, it did not prevent it in all cases. Active warming systems would be required in ensure normothermia. While the monitoring of core temperature is of value, particularly during prolonged operations, assessment of skin temperature provides further important information as to the total heat balance of the patient.

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REFERENCES


REDUCTION OF HEAT LOSS

DIMINUTION DE LA PERTE CALORIQUE EN NEUROCHIRURGIE GRACE A L'UTILISATION DE COUVERTURES PLASTIQUES METALLISEES

RESUME
Nous avons utilisé des couvertures plastiques métallisées (CPM) chez 14 patients neurochirurgicaux et comparé les modifications du contenu calorique de l'organisme au cours de la chirurgie à celles de 14 sujets témoins. Tous les patients, sauf trois du groupe d'étude et un du groupe témoin, avaient perdu de la chaleur à la fin de l'intervention. Il y avait cependant une diminution statistiquement significative de cette perte chez les sujets enveloppes dans la CPM. La mesure de la température cutanée apporte une contribution importante au contrôle de la balance calorique au cours de l'anesthésie.

DIE VERMINDERUNG DES WÄRMEVERLUSTES BEI NEUROCHIRURGISCHEN PATIENTEN DURCH VERWENDUNG VON PLASTIKTUCHERN MIT METALLBESCHICHTUNG

ZUSAMMENFASSUNG

REDUCCIÓN DE LA PÉRDIDA DE CALOR EN PACIENTES DE NEUROCIRUJÍA POR USO DE HOJAS DE PLÁSTICO METALIZADO

SUMARIO
Se uso hojas de plastico metalizado (m.p.s. metallized plastic sheeting) con 14 pacientes de neurocirujía y se llevó a cabo la comparación de la pérdida de calor corporal durante la cirujía de dichos pacientes con un grupo de control de 14 pacientes. Todos los pacientes, salvo tres en el grupo de estudio y uno en el grupo de control, perdieron calor al fin de la operación. Sin embargo, hubo una reducción significante desde el punto de vista estadístico en la pérdida de calor de los pacientes envueltos en las hojas de m.p.s. La medición de la temperatura de la piel contribuye grandemente al control del balance de calor durante la anestesia.