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Heat loss during thoracotomy

A preliminary report

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Our aim in this report is, first, to explain why we think it is important to measure body temperatures during operation and, secondly, to describe a simple way to lessen heat loss during thoracotomy.

We became interested in the subject of heat loss after reading the work of Benzinger (1967), Roe, Goldberg, Blair, and Kinney (1966) and Cuthbertson, Smith, and Tillstone (1968).

Benzinger (1967) from Bethesda has established a quantitative relationship between a fall in body temperature and a rise in metabolic rate. He has summarized some of his findings in a graph which is reproduced in Figure 1. The vertical axis represents the metabolic rate measured in calories of heat produced each second. The basal rate is 20 cal./sec. The horizontal axis represents the deep body temperature (°C.). Each separate line on the graph represents a constant average surface temperature.

Three important facts are shown in this graph:

1. So long as the deep body temperature is higher than 37° C. there is no increase in metabolic rate.

2. So long as the average surface temperature is higher than 33° C. there is no increase in metabolic rate.

3. Only if the deep and average surface temperatures fall below these figures is there an increase in metabolic rate.

Roe *et al.* (1966) from New York measured the oxygen uptake of 24 patients, each of whom had had an abdominal operation. The average increase in oxygen uptake above the basal level was 92% for each degree Centigrade fall in deep body temperature. They did not mention surface temperatures in these patients.

Cuthbertson *et al.* (1968) from Glasgow approached the problem from another angle. They have shown that both rats and humans who are injured and who are nursed in a warm room at a temperature of 30° C. do not produce the so-called 'metabolic response to trauma'. We therefore decided to find out if our patients were losing so much heat during their operations that they were likely to suffer from an increase in metabolic rate during recovery.

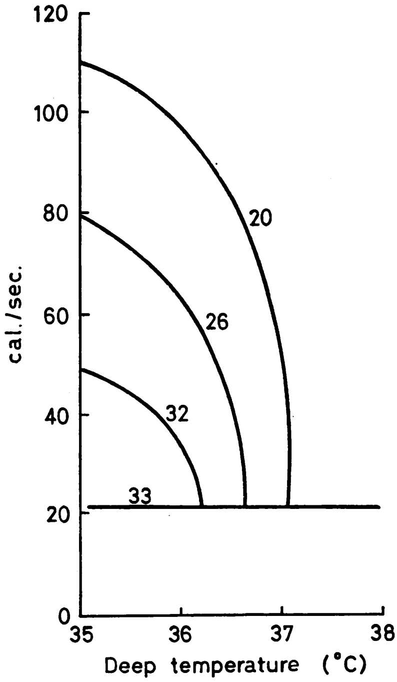

FIG. 1. *Effect of temperature on metabolic heat production (Benzinger). The horizontal line represents a metabolic rate of* 21 *cal./sec.* (75·6 *kcal./hour) at an average skin temperature of* 33° *C. This represents a basal state. The metabolic rate rises as the average skin temperature falls to* 32° *C.,* 26° *C. and* 20° *C. and as the deep temperature falls below* 37° *C.*

INVESTIGATION 1: CONTROL SERIES

We measured the body temperature in 10 patients while they were having a lung or oesophageal operation through a lateral thoracotomy. The composition of this group is shown in Table I

TABLE I

DETAILS OF GROUPS

	Control	Test
No. of patients (M:F)	10 (7:3)	10 (4:6)
Average age, years (S.E.)	56·3 (±2·0)	51·7 (±5·5)
Average weight, kg. (S.E.)	67·9 (±2·2)	63·2 (±4·2)
Average theatre temp., °C. (S.E.) ..	21·2 (±0·3)	21·4 (±0·5)
Average air speed, m./sec.	12	12
Average duration operation, hours (S.E.)	2·8 (±0·2)	2·2 (±0·13)

S.E. = standard error of the mean

under the heading Control Group. Deep body temperatures were measured with a thermistor probe in the rectum or nasopharynx. The average surface temperatures were calculated by the 3-point method of Burton (1935) from measurements on the forearm, abdomen, and calf.

Temperatures were recorded throughout each operation, and the findings are summarized in Table II and Figure 2. The average of the deep

TABLE II

TEMPERATURE CHANGES DURING THORACOTOMY

	Start	Mid	End
Av. surface temp., °C. (S.E.)			
Control group ..	32·97 (±0·47)	32·8 (±0·56)	31·87 (±0·52)
Test group ..	32·61 (±0·24)	32·69 (±0·31)	32·38 (±0·35)
Deep Temp., °C. (S.E.)			
Control group ..	36·37 (±0·23)	35·61 (±0·25)	35·26 (±0·26)
Test group ..	36·68 (±0·23)	36·25 (±0·25)	36·22 (±0·24)
Heat debt, kcal. (S.E.)			
Control group ..		34·2 (±5·9)	58·9 (±6·6)
Test group ..		14·5 (±5·4)	19·5 (±7·2)

and surface temperatures even at the start of the operation were slightly below Benzinger's critical levels and continue to fall in the second half of the operation. Referring to the graph in Fig. 1 we deduce that by the end of the operation there was an average demand for an increase in metabolic rate of over 100%.

IMPLICATIONS OF FINDINGS IN CONTROL GROUP We are disturbed to find that under operating theatre conditions accepted as satisfactory by the medical staff our patients cooled to a level at which their

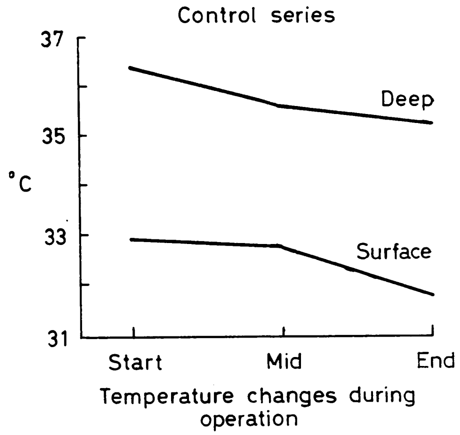

FIG. 2. *Temperature changes during operation.*

metabolic rate was likely to be stimulated to rise by over 100%. An increase of this size is easily tolerated by a healthy person, but we suspected that the elderly ill patient might not be able to tolerate it. For instance, we argued that a patient with heart failure might not be able to increase his cardiac output in the face of an increased metabolic rate, and a patient with renal failure might not be able to excrete the extra load of metabolites that a high metabolic rate produces. We therefore decided that on theoretical grounds it was logical to try to keep our patients warm in the theatre.

ATTEMPTS TO MINIMIZE HEAT LOSS We found it impracticable to reduce heat loss by raising the temperature of the operating room because a temperature higher than 22° C. was not tolerable. Wyon, Lidwell, and Williams (1968) found the same. We therefore had to rely on insulating the patient. For the last 12 months most of our patients have had the lower half of the body wrapped in a blanket of aluminium foil coated with polythene. This blanket is marketed[1] under the name of space blanket. It is available overprinted with lines of carbon black to make it antistatic and it has been approved as safe by physicists from the Ministry of Health. A similar blanket is used for heat conservation by high altitude mountain climbers.

INVESTIGATION 2: TEST GROUP

A second group of 10 patients was selected so as to match the control group as nearly as possible.

[1]Perfusion Associates Ltd., 18 Macaulay Road, London, S.W.4

After induction of anaesthesia the blanket was wrapped around the body so as to envelop it from the waist to the feet. Details of the test group are shown in Table I. We managed a reasonable match between the two groups with the exception of the average length of operation. We shall discuss the importance of this difference later.

The results of using the blanket are given in Fig. 3 and Table II. Deep and surface temperatures in the test group hardly fall at all.

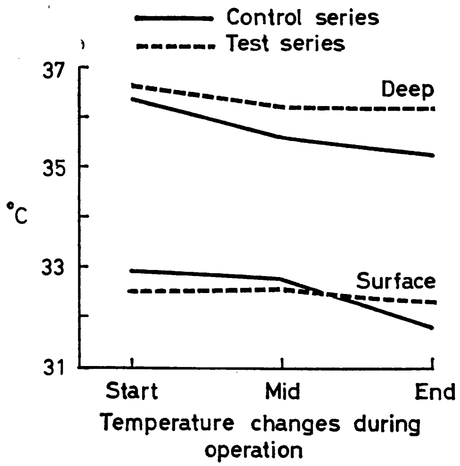

FIG. 3. *Temperature changes during operation.*

By reference to Fig. 1 the demand for an increase in metabolic rate in the test group at the end of the operation is negligible.

We believe that the difference in average length of operation between the two groups is of no real importance. If the slopes representing the temperatures in the test group are extended, it would only increase the difference between the two groups.

The values given for the heat debt in each group are shown in Figure 4. They are calculated by the method of Burton and Edholm (1955). We have expressed heat debt as the number of kilocalories by which heat lost by the patient exceeds heat produced. The average heat debt of 60 kcal. in the control group will require an increase in metabolic rate of about 100% if it is to be repaid within an hour under ideal conditions of insulation. This figure is similar to that predicted for this group by the data given by Benzinger (1967) and Roe *et al.* (1966). The average heat debt of 20 kcal. in the test group represents a stimulus to increase the metabolic rate by only 30%.

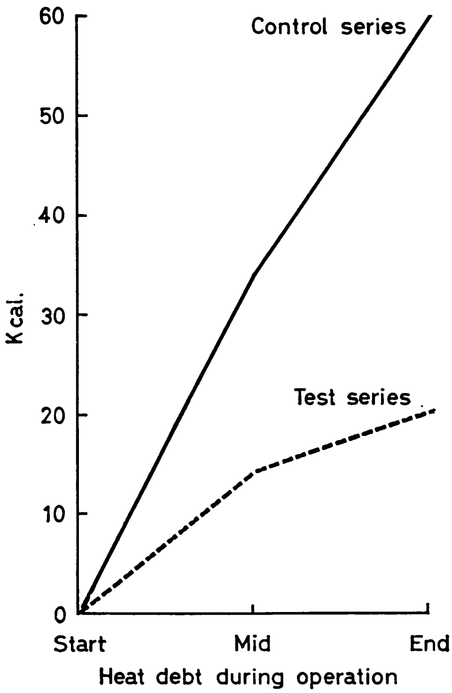

FIG. 4. *Heat debt during operation.*

COMMENT

We have shown that the use of the blanket greatly reduces the heat debt and almost abolishes the fall in body temperature during thoracotomy. The average length of operation in the test group was just over two hours and we cannot draw any conclusions about the value of the blanket in longer operations. It is possible that other methods of warming patients, such as a mattress containing a cellulose gel (Vale and Lunn, 1969) or warm water (Lunn, 1969), might be used in long operations.

The work of Benzinger has shown that a low body temperature provides a powerful stimulus for an increase in metabolic rate. Roe *et al.* (1966) found this increase in the post-operative period in the patients they studied and were able to show a relationship between the amount of fall in deep body temperature and the amount of rise in metabolic rate. Our own measurements of oxygen uptake in the post-operative period are at present too few to make a categorical statement.

What remains to be proved is our hypothesis that the extra strain on the body of producing a high metabolic rate is bad for the patient. As yet we have no facts to offer in this preliminary report, but we feel it is fair to mention the impressions of the nursing and medical staff. They have found that the following clinical features are shown by patients treated essentially in the same way as the test group in this paper, and are not normally shown by those allowed to cool as in the control group. There is a speedy return to full consciousness and satisfactory breathing and there is a stable and adequate flow of urine. The cardiovascular system, as monitored by arterial pressure and central venous pressure, is stable and shivering is rare. This last point deserves to be stressed; the relationship between body temperature and metabolic rate shown in Fig. 1 refers to humans who do not shiver. It is well known that shivering alone can increase oxygen consumption by 400% (Burton and Edholm, 1955).

We must point out one danger of the space blanket. It has proved to be so easy to use that there has been a tendency for it to be used when it is not really necessary. In a warm environment and used on a restless patient there is a danger of producing a dangerously high temperature. We feel that if it is used for longer than half an hour the nasopharyngeal or rectal temperatures should be regularly checked.

This brings us to our main conclusion. We have dealt mainly with the problem of heat loss during operation but are aware that some patients become hyperpyrexial even in an air-conditioned operating room (Stephen, 1967). It seems to us therefore to be important that surface and deep body temperatures of the patient are monitored during surgical operations. It is only by such a routine that a significant rise or fall in body temperature can be recognized early. Such a routine is essential if simple measures such as we have described are to be used effectively to maintain the patient in a state of heat balance.

CONCLUSIONS

The fall in body temperature and the heat debt incurred during thoracotomy have been measured in 10 patients, and both have been found to be significant.

The reason for attempting to minimize these changes is to prevent the metabolic rate rising above basal levels.

The effect on body temperature and heat debt of wrapping the lower half of the body in a heat retaining blanket has been studied in a second group of 10 patients.

The blanket was found to reduce the heat debt and almost to abolish the fall in body temperature.

Clinical impressions of the benefit to the patient when the blanket is used are mentioned. Until our studies are complete, factual evidence on this aspect is lacking.

The need is emphasized for routine monitoring of surface and deep body temperatures during surgical procedures.

We are grateful to Mr. R. H. F. Brain, Director Thoracic Unit, Guy's Hospital, for his co-operation in this study of patients who were under his care.

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