TEMPERATURE CHANGES DURING NEONATAL SURGERY*

BY

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My subject is temperature changes occurring during neonatal surgery. My interest in this subject was stimulated by the obvious cooling which occurred during neonatal operations, the absence in current practice at Great Ormond Street of any special measures to prevent this loss, and the varied methods of rewarming in practice. Also there occurred one or two cases of post-operative sclerema, and it seemed worth while to investigate this temperature loss more fully.

In the past six months or so I have recorded the temperatures, at 10-minute intervals, of 25 infants during operation. Temperatures have been recorded in all cases by a Thermocouple calibrated against an alcohol thermometer reading over the range 20-40° C. and the lead has in all cases been placed in the rectum, except on the two occasions when this would have interfered with the operation. An oesophageal lead was then used. The oesophageal temperature has usually been found, on the occasions when both readings have been taken, to be somewhat higher than the rectal, but the same rate of drop has occurred.

The infants are divided into two groups: in the first 14 the existing practice was followed, no measures being taken to prevent heat loss, and in the next 11 cases the limbs and trunk, apart from the operation site, were insulated with cotton wool held in position by crepe bandages. On later analysis of the type of operations performed it was found that these two groups could fairly be compared.

The average time of operation was 80 minutes and the average temperature loss in the control group was 2.31° C. and in the insulated group 1.56° C. (Table 1). The following are some graphic records of these infants, all of whom were less than 7 days old.

In the control group the greatest loss recorded was in a 6-day-old infant with a diaphragmatic

hernia which was reduced through an abdominal approach. She had a good initial temperature and lost 4° C. in 100 minutes (Fig. 1).

FIG. 1.—J.H., aged 6 days, birth weight 7 lb. 1 oz. Diagnosis: right diaphragmatic hernia.

A characteristic chart is shown in Fig. 2. This is an oesophageal temperature recording, as the baby was having a 'pull-through' operation for anorectal agenesis. There was quite a good initial temperature with a steady loss thereafter until the peritoneum was closed, when there was a slight elevation.

TABLE 1
NEONATAL TEMPERATURE LOSS
(TOTAL CASES RECORDED 25)

Group 1					Group 2				
Controls	..	..	..	14	Insulated	..	..	11	
Average temperature loss 2.31° C.					Average temperature loss 1.56° C.				
Average length of operation 80 mins.									

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FIG. 2.—A.M., aged 12 hours, birth weight 6 lb. Diagnosis: anorectal agenesis.

FIG. 4.—F.D., aged 3 days, birth weight 4 lb. 2 oz. Diagnosis: jejunal atresia.

FIG. 3.—S.T., aged 1 day, birth weight 6 lb. Diagnosis: diaphragmatic hernia.

FIG. 5.—S.W., aged 5 days, birth weight 6 lb. 14 oz. Diagnosis: oesophageal atresia.

Fig. 3 is from another child with a diaphragmatic hernia which was again reduced through the abdomen, although rather more easily than in the first child. This chart shows well the marked and steady temperature drop, the loss being 1.8° C. in 40 minutes. Owing to the diminished differential between the temperature of the child and its environment, it was found, not surprisingly, that the lower the infant's initial temperature, the less the total drop, although the loss does continue (Fig. 4).

There were four cases of oesophageal atresia in the control group. Fig. 5 shows one of these. The temperature losses in these four cases were 1.7° C., 2.6° C., 2.6° C. and 3.5° C.

In the second group of cases, which were insulated, there were three cases of oesophageal atresia. Their temperature losses at operation were 1.6° C., 1.4° C. and 1.2° C., and the chart of one of them (Fig. 6) illustrates well the difference in rate of temperature loss. The operation here was rather

FIG. 6.—D.S., aged 18 hours, birth weight 6 lb. 3 oz. Diagnosis: oesophageal atresia.

FIG. 8.—L.M., aged 2 days, birth weight 4 lb. Diagnosis: ileal atresia.

FIG. 7.—D.G., aged 3 days, birth weight 5 lb. 11 oz. Diagnosis: oesophageal atresia.

shorter than that of the previous case in the control group, but the temperature loss in 80 minutes was 1.4°C . whereas in the uninsulated child it was 3.2°C . in the same time.

A representative chart in the insulated group is of one of the other cases of oesophageal atresia (Fig. 7). This baby had a good initial temperature: there was the initial loss in the first 10 minutes and the loss thereafter was well controlled. Finally

an impressive recommendation for insulation is the chart (Fig. 8) of a 4 lb. (1,800 g.) infant operated upon for ileal atresia. In 65 minutes the total temperature loss was only 0.9°C . The figures of all the recordings are shown in Figs. 9 and 10. In the control group the loss per operation averaged 2.31°C ., or 0.033°C . per minute, and in the insulated group the average loss was 1.56°C . or 0.02°C . per minute.

Points which arose during these recordings were:

(1) In several cases there was a considerable temperature drop between the time the child was brought into the theatre and removed from the incubator and the time the operation was commenced. Such temperature loss can, and should be, avoided.

(2) The diathermy electrode pad used during these operations measured 10×7 cm. The lead plate is enclosed in a cover soaked in saline, and placed under the baby's sacrum. The size of this plate could safely be reduced if especial care were taken in applying the pad, which should be kept unbent; the use of electrode jelly might also help to diminish temperature loss.

(3) Records were taken during these operations of conditions in the theatre. The average theatre temperature was 24.5°C . (76°F .) with a range of $20-26.7^{\circ}\text{C}$.; the average relative humidity was only 50% with a range of 41-64%; the number of persons present in the theatre varied from a minimum of seven to a maximum of 17. The ventilation system during all but one of these operations was changing the theatre air 17 times an hour. A

FIG. 9.—Figures of all the recordings in the control group.

FIG. 10.—Figures of all the recordings in the insulated group.

higher environmental temperature and humidity will reduce heat loss and a temperature of 26.5° C. (80° F.) is not too unpleasant for the surgeon or theatre staff.

The question which, of course, arises is whether temperature loss in these newborn infants matters. Twenty-five cases is too small a series from which to draw any conclusions, but there was no significant difference noticed in the post-operative courses of the infants in these two groups. A vast amount of research has been undertaken of late into hypothermia and its effects, but I venture to suggest that the problem as referable to a newborn baby—and not infrequently a premature baby as well—is rather different from that in older children or adults. We take great care to maintain the temperature of our newborn babies post-operatively (at Great Ormond Street they are almost all nursed in incubators), and it seems irrational not to try to prevent heat loss at operation.

Silverman, Fertig and Berger (1958) reported the result of an investigation to determine the effect of temperature on the survival rates of premature infants. Their results confirmed the view that survival rates can be increased by reducing the heat loss of such infants in the first few days of life. Many neonatal surgical emergencies occur in premature infants, and for full-term infants it seems not unreasonable to suggest that heat conservation is also important. The more premature the infant the more inefficient is its temperature regulating mechanism; a normal baby also has a relatively immature regulating mechanism but after several days, perhaps a week, this mechanism has adapted itself to meet the needs of its new environment. The factors involved in this inability to regulate temperature are the immaturity of the centre itself—Brock

called this 'lack of practice' (Ungeübtheit); the inadequacy of the vasoconstriction and shivering mechanisms; and a relatively large surface area with a small amount of subcutaneous fat, both predisposing to excessive heat loss. On the heat production side it is worth mentioning that although the infant's basal metabolic rate is higher than the adult's, using body weight as a criterion, it is lower when estimated against surface area, and this is even more marked in the premature infant (Smith, 1951).

Rickham (1957) mentioned that in his series no active means were taken at operation to maintain the body temperature and listed three theoretical objections to heating the subject at operation, namely (a) that peripheral vasodilation may have the effect of depriving the vital centres of blood flow, (b) that a low temperature decreases the oxygen need by reducing the metabolic rate, and (c) that hypothermia increases neonatal resistance to anaesthesia.

Peripheral vasodilation is certainly undesirable and it should be remembered, in this context, that it is as easy to overheat an infant as to overcool it. I do not feel that the other two objections offer sufficient justification for allowing a large operative temperature drop.

A brief word about sclerema, the condition characterized by a yellowish-white skin which has a firm resistant feel, which does not pit on pressure and which is fixed to underlying bone and muscle. One case in this series developed the condition. This very ill baby had had a laparotomy elsewhere for intestinal obstruction. He was transferred to Great Ormond Street, was thought to have gastro-enteritis and possibly septicaemia in addition to his obstruction, and at re-operation required a colostomy for Hirschsprung's disease. He was treated with intravenous hydrocortisone immediately post-operatively

as a resuscitative measure. In spite of this he developed gross sclerema. The hydrocortisone was continued and he happily, and somewhat surprisingly, recovered. His initial temperature was 36.4°C . (97.5°F .), his limbs were padded and he lost only 1.4°C . during the operation. Excessive cooling does seem, from reports, to predispose to the development of sclerema, but it seems as if quite frequently, and possibly always, an infective process is involved also.

The conclusions which may be drawn from these investigations therefore are:

(1) Infants at operation may lose a considerable amount of heat. The full biochemical implications of this heat loss are at present unknown, but it is the opinion of one authority at least (Payne, 1959) that they are probably not very important. The effect on the infant's respiration is more immediately important and more easily appreciated. The hypothermia may appreciably delay the return of adequate respirations and predispose to post-operative chest complications.

(2) It is possible to reduce this temperature loss by one-third by the simple expedient of wrapping the infant in cotton wool. A higher theatre temperature than is customary has also been shown to diminish loss.

(3) In the latter part of this series, using insulation and a high environmental temperature, the total loss was reduced by 1°C .- 1.4°C . in several cases.

(4) It seems that if these measures are adopted, active heating by hot water bottle or electric blanket, which has to be carefully controlled during operation, is probably unnecessary.

(5) In view of the expected temperature loss during operation an infant whose temperature is initially low, especially one suspected of having any degree of infection, should probably be warmed before operation is undertaken in order to diminish the risk of development of sclerema neonatorum.

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