Thermoregulation in babies immediately after birth

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SUMMARY The fall in body temperature that occurs in babies soon after birth is influenced by the baby's weight and its environmental conditions. The rate of oxygen consumption $1\frac{1}{2}$ hours after birth was unrelated to body temperature and was only slightly raised, indicating a limited thermogenic capacity. A radiant heater effectively prevented cooling in babies kept with their mothers in the delivery room. Washing soon after birth caused a significant cooling. Healthy term babies were found to have a limited thermogenic response to a cool environment over the first 12 hours of life and efforts to limit heat losses should be concentrated on this period.

Under normal delivery room conditions the newborn baby's body temperature falls rapidly unless efforts are made to prevent cooling. The baby's large surface area in relation to volume, high thermal conductance, and wet surface result in unusually large heat losses. In normal term babies, a metabolic response to cooling is reported to occur within minutes of birth but is insufficient to maintain body temperature until the second or third day of life (Brück, 1961; Hey and Katz, 1969). Both hypoxia and hypercapnia can limit this response and these may be relevant factors in the period immediately after birth (Stupfel, 1959; Scopes and Ahmed, 1966).

Although most obstetric units have a clear procedure for managing the newborn baby, there is no generally accepted policy for minimising heat loss. Washing the baby soon after birth is likely to lead to further heat loss, but it is often considered desirable on social grounds. By measuring the rate of oxygen consumption and body temperature, we have studied both the effects of washing the baby and the value of using a radiant heater during the first $1\frac{1}{2}$ hours of life and have found, contrary to previous reports, that infants have a limited capacity to produce extra heat over the first few hours of life.

Patients and methods

Forty normal term babies delivered vaginally without complications were studied $1\frac{1}{2}$ hours after birth. In 19 no sedation had been given to the mother within 2 hours of delivery and in the remainder

pethidine or pethidine and promethazine had been used. The condition of every baby was good at birth (Apgar score 8 or more at 3 minutes) and after aspiration of the oropharynx the baby was dried and placed well wrapped in a cot in the mother's delivery room at an air temperature of $24.1^{\circ}\text{C} \pm 0.2$ (SEM). Half the babies were provided with additional warmth from a radiant heater (Vickers). This is a fixed output 400 watt radiant heater positioned 0.8 m above the cot surface. The babies were dressed in a nappy and nightshirt and swaddled with two blankets while under the heater. At about 50 minutes after birth half the babies were also subjected to the 'primary toilet' procedure in which the naked baby is cleaned with warm swabs. The procedure took between 10 and 20 minutes.

The 40 babies included in this part of the study were therefore studied sequentially in 4 groups: group 1 were washed and not kept under a radiant heater; group 2 were not washed and not kept under a radiant heater; group 3 were washed and kept under a heater; group 4 were not washed and kept under a heater.

At $1\frac{1}{2}$ hours of age the baby's rate of O_2 consumption was measured using an open circuit system designed for use in the neonatal nursery (Smales, 1978). A mask applied to the baby's face for collection of the mixed expired gases caused only brief restlessness and it was possible to make all measurements during sleep or quiet wakefulness. A stable record of the oxygen content of mixed expired gas could be obtained within 10-20 minutes. After this procedure the baby's rectal temperature was recorded using a standard mercury thermometer inserted 3 cm into the rectum.

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In the second part of the study the rate of O_2 consumption was measured in 32 normal term babies after 20 minutes in a cool environment. All the babies were normal vaginal deliveries and were tested only once, at different ages and at a variable time in relation to their feeds. The temperature of the cool environment was 6°C below the lower limit of the thermoneutral zone as determined from Hey's chart (Hey, 1971). This environment was produced by modifying the incubator temperature to allow for radiant heat loss (Hey and Mount, 1967). After 20 minutes the baby's rate of O_2 consumption and rectal temperature were measured. Maternal consent to the investigation was obtained in every case.

Results

Management in first $1\frac{1}{2}$ hours of life. At $1\frac{1}{2}$ hours of age the mean O_2 consumption was $6.4\text{ ml/kg per min} \pm 0.15$ (mean $\pm$ SE). No significant relationship was found between the rate of O_2 consumption per kg body weight and the baby's birthweight, rectal temperature, room temperature, or the method of management (Fig. 1). Analgesics given during

Fig. 1 O_2 consumption of babies aged $1\frac{1}{2}$ hours according to the method of management (mean $\pm$ SE).

labour did not influence the baby's rate of O_2 consumption at this time. In contrast, rectal temperature at $1\frac{1}{2}$ hours was largely dependent upon the method of management (Fig. 2). Babies in group 1 who had received primary toilet without a radiant heater had the lowest mean rectal temperature of $35.8^\circ\text{C} \pm 0.28$ (mean $\pm$ SE). In group 2 no primary toilet had been carried out resulting in a higher mean rectal temperature of $35.0^\circ\text{C} \pm 0.36$, although this increase was not significant. Babies in

Fig. 2 Rectal temperature of babies aged $1\frac{1}{2}$ hours according to the method of management (mean $\pm$ SE).

group 3 who had received primary toilet and had been warmed with a radiant heater, had a mean rectal temperature of $36.5^\circ\text{C} \pm 0.18$, significantly higher than in groups 1 and 2 ($P < 0.05$, Student's t test). The highest mean rectal temperature of $36.9^\circ\text{C} \pm 0.12$ was found in group 4; these babies were not washed and were warmed with a radiant heater, and their temperature was higher than in group 3 ($P < 0.05$).

Birthweight ranged from 2.38 to 3.97 kg (mean $3.26\text{ kg} \pm 0.06$) and was related to body temperature ($P < 0.01$). There was no significant difference in the mean birthweight of each group.

Room temperature varied between 21.5°C and 27.1°C but was not found to influence the baby's rectal temperature. However, a radiant heater was found to increase the mean room temperature from 23.7 to 24.6°C after $1\frac{1}{2}$ hours ($P < 0.05$). Despite this, there was no significant difference in the mean room temperature of the four groups of babies studied.

Standardised cool exposure. The rate of O_2 consumption measured in 32 normal babies after 20 minutes in a cool incubator is shown related to the age of the baby in hours in Fig. 3. Since a preliminary measurement of O_2 consumption was not made under thermoneutral conditions, the response to cooling is illustrated using a mean minimum value derived from other babies of similar birthweight aged 4–24 hours. A small but highly significant increase in O_2 consumption occurred during the first 24 hours of life ($P < 0.001$). The rate of O_2 consumption after cooling was not related to the timing or amount of maternal analgesia, or to the baby's birthweight or rectal temperature. Birthweight did not influence rectal temperature after this period of cooling.

Fig. 3 O₂ consumption after 20 minutes in a cool environment according to the baby's age in hours. The lower line represents mean minimum O₂ consumption derived from other babies of similar birthweight aged 4–24 hours in a thermoneutral environment.

Discussion

It has already been established that the rapid fall in body temperature occurring after birth can be prevented by drying the baby thoroughly and placing it in an incubator at a thermoneutral temperature. If resuscitation is required, a radiant heater above the naked baby will minimise heat loss during the first 30 minutes of life (Du and Oliver, 1969). This study has shown that a radiant heater can effectively maintain body temperature for an hour and a half while the baby is in the cool environment of the delivery room. Since the unit is not servo controlled, there may be some possibility of overheating and rectal temperature should be checked regularly when the heater is in use for longer than 1½ hours above a well wrapped term baby.

The 'primary toilet' procedure resulted in colder babies, and the drop in temperature was most marked in those under radiant heaters. Washing a baby soon after birth clearly contributes to a fall in body temperature and for this reason it is difficult to justify this practice. The relationship between birthweight and body temperature indicates that low birthweight babies are particularly at risk.

The low rate of O₂ consumption recorded at 1½ hours was a surprising finding when such a high proportion of babies had a low rectal temperature. The mean O₂ consumption of 6.4 ml/kg per min was only 20% greater than the minimum rate recorded by others during the first 12 hours of life

(Brück, 1961; Hey, 1971). In a similar group of babies, Brück showed an increase in heat production of 37% after 60 minutes at 28 °C and 108% after 60 minutes at 23 °C. A fall in metabolic rate with body temperature (the Q10 effect) was not observed and it is unlikely that this phenomenon is relevant in babies of normal birthweight with body temperatures above 35 °C. In the present study no relationship was found between body temperature and O₂ consumption. One explanation for the variation in response to cooling may be an effect noted by Brück (1961) and by Mestyán *et al.* (1962). In cold babies placed in a heat-gaining environment, heat production quickly decreases to minimum, despite a low rectal temperature. Subsequent studies have confirmed that O₂ consumption is predominantly a function of the temperature gradient between body surface and the environment, rather than the absolute values of either deep body or surface temperature (Adamsons *et al.*, 1965).

The standardised period of cool exposure was designed to test this, but O₂ consumption in this heat-losing environment was no greater during the first few hours of life than in those babies warmly swaddled. However, over the whole 24-hour period there was a highly significant increase in O₂ consumption with age. The poor response at 1½ hours is therefore not due to warming of the body surface but represents real limitation in the baby's response to cooling soon after birth. The response improved slowly during the first 24 hours and continues to increase over the first few days of life (Hey and Katz, 1969).

It may be possible to show a larger metabolic response to cold soon after birth if the baby is exposed to a lower environmental temperature for a longer period. Brück (1961), using an environmental temperature of 23 °C for 60 minutes, observed the maximum increase in heat production at 50 minutes after a fall in rectal temperature. Adamsons *et al.* (1965) recorded an O₂ consumption of 15.2 ml/kg per minute in a 3.8 kg baby at 15 °C at 2½ hours of age and concluded that the poor thermal stability of newborn babies cannot be ascribed to impaired heat production. However, it appears that not only is there considerable variation in the response in the first few hours, but that the degree and duration of cooling required to produce an increase in heat production is greater than at any other time.

The increase in response observed in this study over the first hours indicates an increasing capability to compensate for situations of increased heat loss. Radiant heaters can provide valuable support for babies in the cool conditions of the delivery room, but unless environmental temperature is high, the first wash should be delayed.

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