Effect of Body Weight on Temperature Control and Energy Expenditure in Preterm Infants

Tzu-Hui Lei¹, Reyin Lien²*, Jen-Fu Hsu², Ming-Chou Chiang², Ren-Huei Fu²

¹Department of Pediatrics, Ton-Yen General Hospital, Hsinchu, Taiwan
²Division of Neonatology, Department of Pediatrics, Chang Gung Children’s Hospital, Chang Gung University School of Medicine, Taoyuan, Taiwan

Background: The purpose of this study was to compare resting energy expenditure (REE) in premature infants of different body weights during weaning from the incubator. We hypothesized that premature infants would respond to weaning from an incubator with an increase in REE, and that the increment would be larger in infants with lower body weights than in those with higher body weights.

Methods: Stable preterm infants with body weights between 1800–2200 g were enrolled. REE was measured using indirect calorimetry at 1 hour before weaning and 3 hours after turning off the incubator. REE measurements from infants with higher body weight (2000–2200 g, Group A) were compared to those of infants with lower body weight (1800–2000 g, Group B).

Results: A total of 22 patients were studied (10 in Group A and 12 in Group B). REE increased significantly after weaning in both groups (Group A: from 62±7 kcal/kg/day to 69±8 kcal/kg/day, p=0.045 and Group B: from 65±5 kcal/kg/day to 70±7 kcal/kg/day, p=0.001). However, there was no significant difference in REE increments between the two groups.

Conclusion: REE increased significantly in infants during weaning from an incubator. The increase in REE increment was similar in smaller (1800–2000 g) and larger (2000–2200 g) babies in this study. Weaning of preterm babies from an incubator may be safely started when their body weight reaches 1800 g.

1. Introduction

Incubators are necessary to provide a neutral thermal environment for the control of temperature in premature infants. Neonates rely on nonshivering brown fat metabolism for thermogenesis, which consumes oxygen and glucose.¹ Most preterm babies acquire thermal competency and are able to survive at standard room temperature once they reach a body weight (BW) of 1500–2000 g.² The practice of transferring infants from incubators to open cribs varies widely among neonatal units, with no clear evidence for the optimal timing of this transition. Delayed transition to an open crib on the basis of failure to reach an arbitrary BW may result in longer hospitalization than necessary, thus increasing the cost of care. On the other hand, potential risks are associated with making the transition too early. Transferring infants from an incubator to an open crib before they are able to maintain their temperature may result in weight loss or other hypothermia-related complications, and eventually extend hospitalization and add to the cost of care.²,³ Thus, the timing of this transition is of critical relevance.
Energy expenditure may increase for any newborn infant during weaning from an incubator. Preterm, low birth weight infants are in double jeopardy of decreased energy production and increased heat loss. Hence, the smaller the infant, the more energy they might need to spend to maintain optimal body temperature. Increases in energy expenditure may affect optimal BW gain. Energy expenditure needs to be examined to better understand the energy metabolism and nutritional status in premature infants. We hypothesized that there is an increase in resting energy expenditure (REE) during weaning, and that the smaller the infant, the greater the increase in REE during weaning. We analyzed REE with the aim of establishing incubator weaning guidelines based on BW.

2. Patients and Methods

This study was approved by the Institutional Review Board of Chang Gung Memorial Hospital, and written informed parental consent was obtained for each of the participants. The study period was from January to August 2008. We enrolled preterm infants in the Special Care Nursery who were still in incubators, were medically stable, and were in the process of being weaned from the incubator when their BW reached 1800–2200 g. Patients were divided into two groups based on their BW at the beginning of incubator weaning: Group A included infants with higher BWs (2000–2200 g) and Group B included those with lower BWs (1800–2000 g). At the time of study, all infants were receiving full enteral feeding by mouth every 3 hours. All infants had a core temperature between 36.5–37.5ºC for more than 12 hours while in the incubator, and the incubator temperature was set at 31.0 ºC before weaning. At the time of the study, all infants had an energy intake ranging between 85–125 kcal/kg/day. Exclusion criteria included metabolic disorders, bronchopulmonary dysplasia, requirements for supplemental oxygen or respiratory support, major congenital anomalies including congenital heart disease, necrotizing enterocolitis, and severe central nervous system lesions (Grade III & IV intraventricular hemorrhage). Infants with known maternal thyroid disease, withdrawal syndrome, active infection or still under phototherapy were also excluded.

REE was measured by indirect calorimetry using a Deltatrac Metabolic monitor (Datex-Ohmeda, Helsinki, Finland). This instrument has a circuit system that allows continuous measurements of oxygen consumption (VO₂) and carbon dioxide production (VCO₂) using a constant-flow generator. The device self-calibrates before taking measurements based on independently measured barometric pressure. The instrument had an intra-assay coefficient of variation of 3% in the current study. REE measurements were conducted at baseline (1 hour before weaning) and 3 hours after turning off the incubator with the portholes open. All infants were dressed in a similar fashion after the incubator heating was turned off. Each infant’s core temperature was assessed immediately before, and 30 minutes and 60 minutes after turning off the incubator. Weaning failure was defined as an infant’s core temperature dropping below 36.5ºC after the incubator was turned off with the portholes open. The incubator was turned on again if weaning failed. The room temperature of the study site was maintained within the range of 24.5–26ºC using a central air conditioning system. All measurements were started 1 hour after feeding, while infants were quiet and asleep. All infants were fed every 3 hours. Each measurement lasted a total of 40 minutes, with the examiner observing patients from the bedside and with each patient receiving two measurements before and after weaning. Measurements were stopped during the patient’s body movement and resumed when movement stopped.

Data were presented as mean±SD. Differences in continuous variables were analyzed using Student’s t tests, paired t tests and linear regressions. Differences in categorical variables were analyzed using χ² tests. Results were considered statistically significant at p<0.05.

3. Results

A total of 22 preterm infants were included in the study, 10 in Group A (higher BW) and 12 in Group B (lower BW). BW, gestational age at birth and study weight were 1864±413 g and 1714±286 g, 33.0±2.4 weeks and 33.9±2.4 weeks, 2105±86 g and 1901±38 g, in Groups A and Group B, respectively. Postmenstrual ages were similar at the time of study: 35.8±1.2 weeks in Group A and 36.1±1.2 weeks in Group B. There were no significant differences in birth BW, gestational age or study age between the two groups of infants (Table 1). Five infants in Group A and three in Group B were male. All but one infant in Group B were successfully weaned from the incubator. One infant in the lower weight group failed incubator weaning and developed hypothermia and bradycardia. The weaning success rate was similar between the two groups.

At the time of study, all infants had energy intake that was between 86–124 kcal/kg/day (mean±SD, 106±13 kcal/kg/day and 113±14 kcal/kg/day in Group A and Group B, respectively). The infants were fed orally with human milk and fortifier or preterm formula. No infants required the use of an orogastric
at the time of the study. The infants’ energy expenditures are summarized in Table 2. REE increased significantly 3 hours after turning off the incubator or in REE increment. Of either REE before or after weaning from the incubator, and none were receiving parenteral nutrition. 180 kcal/kg/day vs. 64±5 kcal/kg/day Group A vs. B), or after weaning (70±9 kcal/kg/day vs. 71±7 kcal/kg/day, Group A vs. B). The REE increments were also similar between the two groups.

The only infant who failed to be weaned from the incubator weighed 1890 g, and its REEs before and after weaning were 63.9 kcal/kg/day and 60.1 kcal/kg/day, respectively. Energy intake was 113 kcal/kg/day.

4. Discussion

This study confirmed that preterm infants respond to weaning from an incubator by increasing their metabolic rate and REE. The study results reiterate the importance of meticulous integration of thermogenesis, nutritional supply and growth into the care of preterm infants. Our results also suggest that there was no greater increase in REE associated with weaning for infants weighing over 1800 g than for those weighing over 2000 g. The weaning success rate and daily weight gains during transfer from incubators to open cribs were similar for infants with lower and higher BWs. At present, no clear guidelines exist to suggest when preterm infants should be weaned from an incubator, and 2 kg is used as a random weaning weight in some nurseries. The results of the current study suggest that it is safe to try weaning infants from an incubator when they reach a BW of 1800 g.

It has long been suggested that SGA infants have a higher metabolic rate than AGA infants, leading to the concept of a relatively higher energy expenditure in SGA infants. This increased energy expenditure in SGA infants is partly explained by their having relatively less subcutaneous fat for insulation and thermogenesis, and having a greater surface area/weight ratio in comparison with AGA infants. SGA infants in the current study also had higher REEs. However, even when the three SGA infants were excluded, there was still no difference in REE between the groups either before (62±8 kcal/kg/day vs. 64±5 kcal/kg/day Group A vs. B), or after weaning (70±9 kcal/kg/day vs. 71±7 kcal/kg/day, Group A vs. B). The REE increments were also similar between the two groups.

The only infant who failed to be weaned from the incubator weighed 1890 g, and its REEs before and after weaning were 63.9 kcal/kg/day and 60.1 kcal/kg/day, respectively. Energy intake was 113 kcal/kg/day.

Mean BW gains 3 days after weaning were 18±8 g/kg/day and 17±7 g/kg/day in Groups A and B (p>0.05), respectively. Mean BW gains within the 3 days before weaning were 17±7 g/kg/day and 14±6 g/kg/day in Groups A and B (p>0.05), respectively. No differences in BW gains between Groups A and B were found before or after weaning, using paired t tests. Energy balance can be expressed as energy intake minus REE. No correlation between mean weight gain during weaning and infant’s body weight or energy balance was found using linear regression analysis. Taking all study infants as a whole, REE, gestational age, postmenstrual age, birth BW and postnatal age were 64±6 kcal/kg/day, 33.4±1.9 weeks, 35.9±1.9 weeks, 1776±349 g and 19±12 days, respectively. Analyses of correlations between baseline REE (immediately before weaning, taking all study infants as one group) and other factors showed that only postnatal age correlated with baseline REE (p=0.010), that is, the older the postnatal age, the higher the REE.

Table 1 Demographic characteristics of the study infants

<table>
<thead>
<tr>
<th></th>
<th>Group A (n=10)</th>
<th>Group B (n=12)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (g)</td>
<td>1864±413</td>
<td>1714±286</td>
<td>0.33</td>
</tr>
<tr>
<td>Gestational age (wk)</td>
<td>33.0±2.4</td>
<td>33.9±2.4</td>
<td>0.52</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>5/5</td>
<td>3/9</td>
<td>0.17</td>
</tr>
<tr>
<td>Weight at weaning (g)</td>
<td>2105±86</td>
<td>1901±38</td>
<td>0.01†</td>
</tr>
<tr>
<td>Postmenstrual age</td>
<td>35.8±1.2</td>
<td>36.1±1.2</td>
<td>0.75</td>
</tr>
</tbody>
</table>

*Data presented as mean±SD; †p<0.05.

Table 2 Energy expenditure and energy intake (kcal/kg/day)

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>REE before weaning</td>
<td>62±7</td>
<td>65±5</td>
<td></td>
</tr>
<tr>
<td>REE after weaning</td>
<td>69±8</td>
<td>70±7</td>
<td></td>
</tr>
<tr>
<td>Energy intake</td>
<td>106±13</td>
<td>113±14</td>
<td></td>
</tr>
<tr>
<td>BW gain (g/kg/day)</td>
<td>18±8</td>
<td>17±7</td>
<td></td>
</tr>
</tbody>
</table>

*Data presented as mean±SD; †p<0.05 (before and after weaning). REE=resting energy expenditure; BW=body weight.
with previous studies that reported improved thermal stability with increasing postnatal age.

Weaning failed in only one patient in the current study, and the REE was lower in this infant after weaning, compared with the others. This could be explained by the patient’s hypothermia and lower metabolic status (lower heart rate during hypothermia). Weintraub et al compared REE in 42 preterm neonates divided into two incubator weaning methods. They suggested that baseline REE was higher in the successfully weaned group than in the failed group, and that higher baseline REE conferred a homeothermic advantage. However, baseline REE in the failed patient in our study was not significantly different from that of the successfully weaned infants. Only premature infants weighing above 1800 g were enrolled in this study, which may have contributed to the higher successful weaning rate from the incubator. This could explain why only one patient in our study failed weaning.

This study was limited by the fact that it was not a case-controlled study, and the case number was suboptimal. However, the sound clinical observations may help guide decision making by pediatricians responsible for the care of preterm infants. The results of this study also provide the basis for further investigations using larger sample sizes and focusing on infants with lower BWs than those used in the current study.

In summary, REE increases significantly after an infant is weaned from an incubator. Medically stable preterm infants may be safely weaned from an incubator when their BW reaches 1800 g, thus effectively reducing their hospital stay.

References