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Indirect calorimetry: a tool to adjust energy expenditure in very low birth weight infants

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Abstract

Objective: To determine the resting metabolic rate in very low birth weight infants through indirect calorimetry.

Methods: Cross-sectional study including 29 clinically stable very low birth weight infants receiving an enteral diet > 100 kcal/kg/day. Malnutrition was defined as weight-for-age z score ≤ - 2 SD. Resting energy expenditure was measured using open circuit indirect calorimetry.

Results: At the time of the examination, mean weight was 1,564±393 g and corrected gestational age was 35±3 weeks. Malnutrition was diagnosed in 62.1% of the preterm infants. The mean resting metabolic rate was 57.01±7.76 kcal/kg/day.

Conclusion: Since resting energy expenditure is the main caloric component of total energy expenditure, the high resting metabolic rate observed may have a strong impact on the development of malnutrition during hospitalization.

J Pediatr (Rio J). 2007;83(6):567-570: Nutrition, indirect calorimetry, preterm infant.

Introduction

Providing adequate nutrition to preterm newborns (NB) is one of the great challenges of neonatology. Although the importance of nutritional management in NB is well recognized, the required amounts of most nutrients have not yet been established. Such uncertainties may lead to limited intake of certain nutrients, which in early periods of life may have a long-term impact on development.[1]

The main objective of neonatal nutrition is to ensure a growth rate that is similar to that occurring intra-uterus; thus, factors such as resting metabolism, physical activity, maintenance of body temperature, digestion, synthesis and losses must be taken into account when prescribing a diet to NB.[2]

There are various methods to measure energy expenditure, such as direct and indirect calorimetry, double labeled water and the Fick principle. Among these, worthy of note is indirect calorimetry, a practical, safe, non-invasive and portable method that determines energy expenditure based on VO_2 and carbon dioxide production through analysis of the air inspired and exhaled from the lungs. In addition, indirect calorimetry is considered as the most adequate and safest method for NB, and can be used to measure expenditure for prolonged periods of time.[3]

The objective of this study was to determine the resting energy expenditure in very low birth weight infants using indirect calorimetry.

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Methods

Population

A cross-sectional study was carried out with a group of NB admitted between June and December, 2005 to the neonatal intensive care unit at Instituto Fernandes Figueira, Rio de Janeiro, Brazil, with birth weight < 1,500 g. NB with congenital malformation or infection, grade 3 and 4 intracranial hemorrhage and sepsis were excluded from the study. The sample size was estimated to be 29 NB for a significance of 95% and a power of 80%. The estimates for the calculation of sample size were obtained from previous studies using the same method.[4] All the NB admitted in the study period who met the inclusion criteria and whose mothers agreed to participate were consecutively enrolled until the sample size was met.

An evaluation was performed after the 14th day of life and as soon and the NB were considered to be clinically stable, breathing ambient air and receiving an enteral diet > 100 kcal/kg/day exclusively.[4] All the NB were growing and had recovered their birth weight; 81.3 % were receiving a mixed diet (fortified human milk and formula). None was receiving any medications (aminophylline, caffeine or digitalis, anticonvulsivants) or presented diseases (sepsis, bronchopulmonary dysplasia) that could interfere with metabolic expenditure. Gestational age at birth was obtained based on the date of the last period, confirmed by first trimester ultrasound and, in case of doubt, by the method of Ballard et al.[5]

The weight-for-age z score was used to evaluate nutritional adequacy, based on the Canadian Reference for Birth Weight for Gestational Age.[6] Malnutrition was defined as weight-for-age z score ≤ -2 (close to the 3rd percentile), according to World Health Organization (WHO) criteria.[7]

Metabolic assessment

The measurement of resting energy expenditure, oxygen consumption (VO_2), output of carbon dioxide (VCO_2) and respiratory quotient (RQ) was performed using indirect calorimetry with the Deltatrac II Metabolic Monitor. This equipment employs an open circuit that enables continuous measurement of VO_2 and VCO_2 through a constant flow generator. Indirect calorimetry measurements began 1 hour after administration of the diet. Test duration was 20 minutes after stabilization of the apparatus.[8] Readings were obtained through a bell jar place on the NB's face. The infant was maintained in a quiet and comfortable position in the incubator in the thermal comfort zone according to the Scopes & Ahmed[9] table. The temperature was monitored using a servocontrol device adapted to the baby's skin. The test was interrupted if the infant became restless or began to cry, following a scale correlating body activity with energy expenditure.[10]

Statistical analysis

Statistical software was used to set up a database and analyze the variables. The variables were described through frequency measures, means and standard deviations.

The study was approved the Human Research Ethics Committee at Instituto Fernandes Figueira. All the participants signed an informed consent form.

Results

We studied 29 NB with mean birth weight of 1,210±231 g and 31±3 of gestational age at birth. The characteristics of the study population at birth and at the evaluation appear in Table 1.

Concerning nutritional status, we observed a significant increase (21 to 62.1%) in the number of NB with a weight for age z score ≤ -2.0 at birth vs. at evaluation.

The resting energy expenditure of the study population according to indirect calorimetry was 57.01±7.76 kcal/kg/day. Of the 29 NB, only six (20.6%) had a resting energy expenditure between 40 and 50 kcal/kg/day, the reference value for the American Academy of Pediatrics (AAP).

Discussion

Very low birth weight infants are a group at nutritional risk, and thus the studies focused on nutrition and its impact on growth are important in this group. Insufficient weight gain may be a marker of inadequate nutrition, which in turn may impact cognitive development, with a decrease in brain cells.[11]

For the AAP, the quality of postnatal weight gain depends on the type, amount and quality of the diet.[2] In our environment, there is evidence that up to 63% of preterm NB may be suffering from malnutrition by the time they reach the term corrected age.[12] Many factors can contribute to this inadequate weight gain: incorrect estimates of metabolic rate, insufficient offer and inadequate absorption of nutrients in the presence of a high nutrient excretion rate.

In extremely premature patients, the use of indirect calorimetry may provide important information for nutritional management, because the energy expenditure in these patients varies widely. Estimates based exclusively on generic predictive equations may underestimate the real needs of this group, affecting growth and development and consequently quality of life.[3]

According to the AAP, the resting energy expenditure of preterm low birth weight NB ranges from 40 to 50 kcal/kg/day.[2] Studies with indirect calorimetry, which has been used to determine the resting energy expenditure of NB, are extremely important, because the magnitude of the change in energy expenditure may have long term consequences for growth.[13] Bauer et al.[4] studied premature NB with gestational age below 30 weeks and found a resting energy expenditure of 53±6 kcal/kg/day on the 21st day of life. Putet et al.[14] assessed the resting energy expenditure of very low birth weight NB at 36 weeks of corrected age and reported an energy expenditure of 51.5±2.9 kcal/kg/day when fed a pool of pasteurized human milk vs. 63.3±4,5 kcal/kg/day when

Table 1 - Characteristics of very low birth weight newborns admitted to a neonatal intensive care unit at birth and at the moment of evaluation

Variable	Mean ± standard deviation
At birth	
Weight (g)*	1,210±231
Gestational age (weeks)*	31±3
z score*	-1.3±1.2
Malnourished, n (%)	7 (21%)
Evaluation	
Weight (g)*	1,564±393
Corrected age (weeks)*	35±3
z score*	-2.1±1.5
Malnourished, n (%)	22 (62.1%)
Indirect calorimetry	
Resting energy expenditure (kcal/kg/day)*	57.01±7.76
VCO_2 (mL/kg/min)*	6.74±2.33
VO_2 (mL/kg/min)*	7.33±2.56
RQ*	0.92±0.08

* Mean ± standard deviation.
RQ = respiratory quotient; VCO_2 = carbon dioxide output; VO_2 = oxygen consumption.

fed a formula specifically designed for preterms. Like the present results (57.01±7.76 kcal/kg/day), the findings reported by these studies are higher than the expenditure suggested by the AAP,[2] which shows that the recommended calorie intake should be revised, since very low birth weight infants may be spending more energy to maintain vital processes and consequently increasing their calorie needs. This may be reflected in the inadequate weight gain reported in the present study.

Basal energy expenditure is the amount of energy required to maintain vital processes under controlled and standardized conditions while the individual is at rest in adequate ambient temperature. Resting energy expenditure corresponds to the amount of energy required under similar conditions, except that it can be measured after meals or normal activity. In NB and infants, resting energy expenditure is similar to basal energy expenditure.[15]

The high resting energy expenditure observed by us may have a strong impact on the development of malnutrition during hospitalization. Basal energy expenditure is the main calorie component of total energy expenditure, and thus correct knowledge of this aspect is essential for adequate calorie prescription.

The correlation of energy expenditure with clinical status, type of milk provided, use of drugs such as xanthines, among others, still needs to be assessed by specific studies, since the design and sample size in the present exploratory study are not adequate to address these issues.

Studies like the one reported here, using indirect calorimetry, are important in this age group because they may determine the need to revise the nutritional needs of preterm infants so as to ensure adequate growth and development.

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