Intensive Care Med (2014) 40:120–122
DOI 10.1007/s00134-013-3123-5

LETTER

**G. Briassoulis**
**E. Briassouli**
**T. Tavladaki**
**S. Ilia**
**D. M. Fitrolaki**
**A. M. Spanaki**

# Unpredictable combination of metabolic and feeding patterns in malnourished critically ill children: the malnutrition–energy assessment question

Accepted: 21 September 2013
Published online: 17 October 2013


Presented in part at ESPNIC, Rotterdam, 14 June 2013.

Dear Editor,

Advances in paediatric critical care have resulted in the increased survival of chronically ill patients. In many units, such patients represent >50 % of the workload and are often malnourished [1]. Prediction of energy expenditure (PEE) equations are simple alternatives to the gold standard of assessing resting energy expenditure (REE) by indirect calorimetry (IC). However, recent work has suggested that PEE equations fail to adequately predict REE. New paediatric intensive care unit (PICU)-oriented equations have been found to be no better than well-established tools, such as the Schofield-HW equation [2]. We have compared PICU-specialized and commonly used PEE equations with REE using a new modular metabolic monitor (E-COVX) in well-nourished and malnourished critically ill children. The E-COVX compact metabolic module has the advantage of not being influenced by uneventful open endotracheal suctioning [3]. It is suitable for repeated 30-min measurements in well-sedated mechanically ventilated children with stable respiratory patterns in a variety of ventilation modes [4]. We hypothesized that IC using the E-COVX would show that energy expenditure is unpredictable in malnourished children and that replacing REE with any PEE equation, including the new PICU-oriented equations, might not be applicable for estimating energy expenditure in patients suffering from malnutrition during a critical illness. The Ethics Committee of the Institutional Review Board approved this study, and parents or guardians of the children gave informed, written consent.

Mechanically ventilated critically ill children, consecutively admitted to the PICU of the University Hospital, Heraklion, Crete, were enrolled in the study. Thirty consecutive 1-min gas exchange measurements ($VO_2$ and $VCO_2$) were taken and the respiratory quotient (RQ) and REE were calculated for each patient (results were blinded from the attending physician). The nutritional status was evaluated for the presence of protein-energy malnutrition as defined by Waterlow [5]. The PEE was estimated and basal metabolic rate (PBMR) was predicted using the common Harris–Benedict, Schofield–HW, Seashore, Fleisch, Caldwell–Kennedy and Henrys formulas, as well as equations specifically developed for the PICU by White and by Meyer [2]. Patients were classified as hypermetabolic, normometabolic and hypometabolic when the REE was >110, 90–110 and <90 % of the Schofield–PBMR, respectively, and as overfed, adequately fed and underfed when the caloric intake was >110, 80–110 and <80 % of the REE, respectively.

Forty-four patients (28 boys, 16 girls) were studied (total measurements 1,320). Four patients were admitted after an elective procedure; the remaining patients were admitted as a result of an acute illness or injury. Twelve (27.3 %) patients presented severe (4) or moderate (8) malnutrition. All patients survived.

The REE did not differ between patients according to a body temperature of <37.1 °C (1,068 ± 460 kcal/day) or ≥37.1 °C (824 ± 217 kcal/day) or with a Ramsey sedation score of >3 versus ≤3 (956 vs. 915 kcal/day). The mean differences between the non-malnourished and malnourished groups of patients were non-significant when calculated using the REE (178 ± 119 kcal/day, $p < 0.3$), the White PEE equation (−80 ± 133 kcal/day, $p < 0.6$), and the Meyer PEE equation (−171 ± 101 kcal/day, $p < 0.09$). In contrast, the PEE calculated according to the Schofield–HW equation was lower in the malnutrition group (−251 ± 186 kcal/day, $p < 0.05$), even though malnourished patients were fed more compared to the non-malnourished (399 ± 96 kcal/day, $p < 0.0001$) (Fig. 1a).

In the non-malnourished group, the Schofield equation was shown to overestimate REE compared to the two PICU-oriented PEE ($p < 0.0001$). In the malnourished group, REE was lower than the PEE calculated using the Schofield-HW equation ($p < 0.0001$), the White equation ($p < 0.02$), and the Meyer equation ($p < 0.04$) (Fig. 1a). Also, compared to the non-malnutrition group where energy intake was lower than REE (−256 ± 430 kcal/day, $p < 0.002$), energy intake in the malnutrition group was higher than REE (301 ± 325 kcal/day, $p < 0.02$). A contrasting combination of hypo-metabolism and over-feeding (79.8 ± 24 % vs. 145 ± 68 %, $p = 0.0001$) was demonstrated in the malnourished group of patients (Fig. 1b).

Although new PICU-oriented PEE equations are the least likely to overestimate REE and therefore preferred when REE cannot be

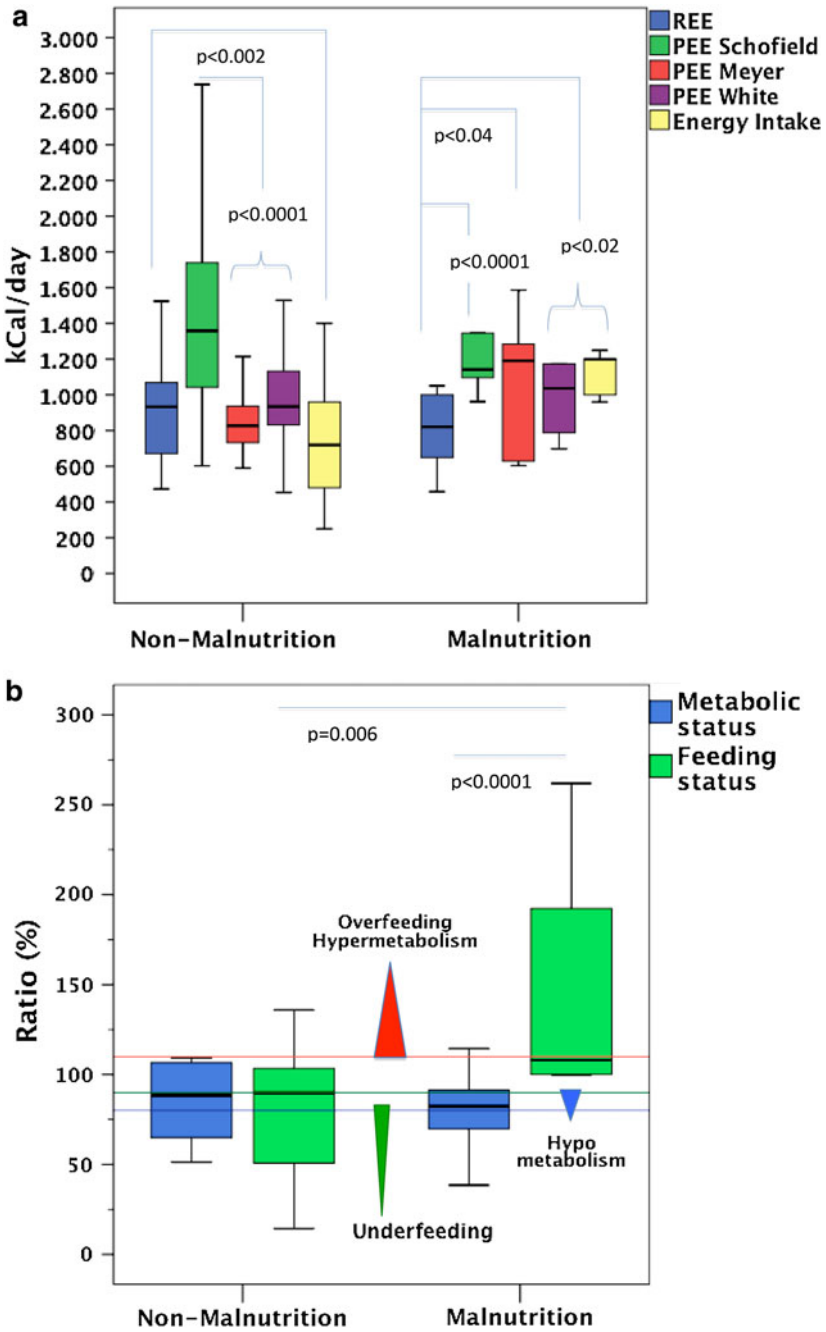


**Fig. 1** Boxplots of energy intake and resting energy expenditure (REE) measured by indirect calorimetry (IC) or by the prediction of energy expenditure (PEE) equation of Schofield-HW and the paediatric intensive care unit-specific White and Meyer equations in patients presenting with or without malnutrition during critical illness (**a**) and of feeding and metabolic patterns in patients presenting with or without malnutrition during critical illness (**b**). *Reference lines* indicate levels of metabolic and feeding status, *bold black line* in *box plots* indicates the median per group, *bottom of the box* indicates the 25th percentile, *top of the box* represents the 75th percentile; the T-bars (*whiskers*) and *horizontal lines* show the minimum and maximum values of the calculated non-outlier values

measured, a real danger might be an acute stress–nutrition support imbalance. This imbalance might lead to either insufficient autophagy or a failure to induce mitochondrial biogenesis [6]. A combination of hypometabolic/hyperfeeding patterns in malnourished children might indicate an interplay between ATP supply and demand, dictated by the degree of mitochondrial dysfunction and the level of metabolic shutdown

in the acute stress state [6]. Thus, overfeeding during a critical illness might evoke a phenotype of autophagy deficiency and advance insufficient mitophagy as a potentially important contributor to mitochondrial and organ damage during the critical illness [7]. Accordingly, while nutritional risk continues to be unrecognized and undertreated in clinical practice, malnourished patients have been shown to be candidates for IC per A.S.P.E.N. (American Society for Parenteral and Enteral Nutrition) guidelines [8].

**Conflicts of interest** None.

## References


1. Briassoulis G, Filippou O, Natsi L, Mavrikiou M, Hatzis T (2004) Acute and chronic paediatric intensive care patients: current trends and perspectives on resource utilization. QJM 97:507–518
2. Meyer R, Kulinskaya E, Briassoulis G, Taylor RM, Cooper M, Pathan N, Habibi P (2012) The challenge of developing a new predictive formula to estimate energy requirements in ventilated critically ill children. Nutr Clin Pract 27(5):669–676
3. Briassoulis G, Briassoulis P, Michaeloudi E, Fitrolaki DM, Spanaki AM, Briassouli E (2009) The effects of endotracheal suctioning on the accuracy of oxygen consumption and carbon dioxide production measurements and pulmonary mechanics calculated by a compact metabolic monitor. Anesth Analg 109(3):873–879
4. Briassoulis G, Michaeloudi E, Fitrolaki DM, Spanaki AM, Briassouli E (2009) Influence of different ventilator modes on Vo(2) and Vco(2) measurements using a compact metabolic monitor. Nutrition 25(11–12):1106–1114
5. Waterlow JC (1972) Classification and definition of protein-calorie malnutrition. Br Med J 3:566–569
6. Singer M (2007) Mitochondrial function in sepsis: acute phase versus multiple organ failure. Crit Care Med 35(9 Suppl):S441–S448
7. Gunst J, Derese I, Aertgeerts A, Ververs EJ, Wauters A, Van den Berghe G, Vanhorebeek I (2013) Insufficient autophagy contributes to mitochondrial dysfunction, organ failure, and adverse outcome in an animal model of critical illness. Crit Care Med 41(1):182–194
8. Kyle UG, Arriaza A, Esposito M, Coss-Bu JA (2012) Is indirect calorimetry a necessity or a luxury in the pediatric intensive care unit? JPEN J Parenter Enteral Nutr 36(2):177–182



G. Briassoulis (✉) · T. Tavladaki · S. Ilia · D. M. Fitrolaki · A. M. Spanaki
Pediatric Intensive Care Unit, School of Health Sciences, University Hospital of Heraklion, University of Crete, 71110 Heraklion, Crete, Greece
e-mail: ggbriass@otenet.gr
Tel.: +30-2810-375024
Fax: +30-2810-392652

E. Briassouli
1st Department of Internal-Medicine, Propaedeutic, University of Athens, Athens, Greece