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Relationship between energy expenditure, nutritional status and clinical severity before starting enteral nutrition in critically ill children

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Abstract

The objective of the present study was to investigate the relationship between energy expenditure (EE), biochemical and anthropometric nutritional status and severity scales in critically ill children. We performed a prospective observational study in forty-six critically ill children. The following variables were recorded before starting nutrition: age, sex, diagnosis, weight, height, risk of mortality according to the Paediatric Risk Score of Mortality (PRISM), the Revised Paediatric Index of Mortality (PIM2) and the Paediatric Logistic Organ Dysfunction (PELOD) scales, laboratory parameters (albumin, total proteins, prealbumin, transferrin, retinol-binding protein, cholesterol and TAG, and nitrogen balance) and EE measured by indirect calorimetry. The results showed that there was no relationship between EE and clinical severity evaluated using the PRISM, PIM2 and PELOD scales or with the anthropometric nutritional status or biochemical alterations. Finally, it was concluded that neither nutritional status nor clinical severity is related to EE. Therefore, EE must be measured individually in each critically ill child using indirect calorimetry.

Key words: Energy expenditure: Indirect calorimetry: Malnutrition: Critically ill children: Severity of illness scores

Nutrition is one of the cornerstones of management of critically ill paediatric patients. Between 40 and 70% of critically ill children present some degree of malnutrition, and this impairs the response to disease and increases the susceptibility to infection and to the onset of multi-organ failure, leading to a substantial rise in morbidity and mortality[1–5].

The most appropriate form of energy delivery and the nutrient composition for these patients still remains to be established[1,2,5]. Although some critically ill children present a hypermetabolic state (major burns, multiple injuries and prolonged admission), the majority have a lower energy expenditure (EE) than healthy children, particularly those on mechanical ventilation or with sedation and muscle relaxation[6–12].

Insufficient energy delivery leads to depletion of fat and protein reserves, reducing the ability of the body to react to aggression and impairing the immune response, increasing the susceptibility to infection[1–5]. An excessive energy delivery over a long period, on the other hand, can cause hepatic steatosis and an increase in CO_2 production, prolonging the time on mechanical ventilation. There is enormous variability in the nutritional requirements of critically ill children[6–8,13–16]; it is therefore important to adjust energy delivery individually to the EE of each patient[7,8,15–17].

Although there are numerous formulas for calculating the energy delivery that critically ill children require, none of them has been shown to have good concordance with true EE[6–8,12–18]. Indirect calorimetry is the best method for measuring EE in critically ill children, but its use has still not become widespread, and even today many paediatric intensive care units (PICU) continue only to use the formulas[19,20].

The objective of the present study was to determine whether there is any relationship between EE and biochemical and anthropometric nutritional status and clinical severity on admission to the intensive care unit. The hypothesis of the present study was that children with lower anthropometric and biochemical protein parameters of nutrition have lower EE. The presence of a relationship would enable energy delivery to be adapted to the theoretical expenditure in these patients.

Abbreviations: EE, energy expenditure; PICU, paediatric intensive care unit; PRISM, Paediatric Risk Score of Mortality.

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Patients and methods

A prospective observational study was performed. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving patients were approved by the local Institutional Review Board. Written informed consent was obtained from the parents of the participating children. The study population comprised of patients aged between 1 month and 16 years admitted to the PICU, on mechanical ventilation, with a fraction of inspired oxygen ≤ 60 %, and who were nil-by-mouth before starting enteral nutrition, only receiving intravenous glucose infusions. Patients on high-frequency mechanical ventilation or extracorporeal membrane oxygenation were excluded due to the technical difficulty of measuring EE.

Epidemiological and anthropometric variables (age, sex, diagnosis on admission, weight and height) were recorded. The risk of mortality was calculated using the Paediatric Risk Score of Mortality (PRISM)[21], the Revised Paediatric Index of Mortality[22] and the Paediatric Logistic Organ Dysfunction[23] scales. The following laboratory parameters of nutrition were measured in serum: prealbumin, transferrin, retinol-binding protein by nephelometry using the BN2 Siemens (Medical Solutions Diagnostics GmbH, Bad Nauheim, Germany), and albumin (turbidimetry), total proteins (turbidimetry–Biuret), urea (enzymatic-UV ureasa), cholesterol and TAG (enzymatic-UV turbidimetry) using the Cobas Integra 400 plus (Roche Diagnostica, Hoffman-La Roche, Basel, Switzerland). Urinary urea was determined (enzymatic-UV ureasa turbidimetry) using the Cobas Integra 400 plus (Roche Diagnostica), and nitrogen balance was calculated.

Before starting the nutrition, baseline calorimetry was performed in all patients using the Datex S5 monitor (E-COVX; GE Healthcare/Datex-Ohmeda, Helsinki, Finland). The duration of the measurement was between 1 and 2 h and, during that time, the respiratory support parameters were not altered. The following data were recorded: VO_2, CO_2 production, EE and the respiratory quotient.

Based on weight on admission, patients were classified into underweight (weight lower than tenth percentile for age and sex) and normal-weight (weight above tenth percentile) groups according to the local standard references[24]. The children also were grouped according to a risk of mortality higher or lower than 5 %, based on the PRISM, the Paediatric Logistic Organ Dysfunction and the Revised Paediatric Index of Mortality scores.

Statistical analysis was performed using the SPSS version 16.0 statistical package (SPSS, Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used to determine normality of the data. The χ^2 test, Fisher's exact test, Mann–Whitney and Kruskal–Wallis tests were used to compare the qualitative and quantitative variables. Correlations were determined using the Pearson and Spearman tests. Significance was taken as a P value $<0{\cdot}05$.

Results

The study population comprised of forty-six patients aged between 1 month and 16 years. Of these, 63 % were less than 1-year-old and 56·5 % were male. The reason for admission to the PICU was for postsurgical care in thirty-six patients (78·2 %; thirty in the postoperative period of cardiac surgery and six after surgery to the airway) and for medical conditions in ten patients (21·8 %; three with heart failure, four with respiratory failure, one with sepsis, one with meningoencephalitis and one with multiple injuries). The median duration of PICU admission and mechanical ventilation before the beginning of the study was 18 and 20 h, respectively (range 12–48 h) for both measures. None of the patients died during the study.

Table 1 shows the clinical and anthropometric characteristics and the biochemical nutritional parameters. Body weight was below the tenth percentile in 71·7 % of the patients and below the third percentile in 58·7 % of the patients. The percentage of patients who presented alterations in the biochemical nutritional parameters according to our paediatric local reference values was as follows: total proteins < 45 g/l, 15·6 %; albumin < 30 g/l, 26·7 %; prealbumin < 100 mg/l, 35·3 %; retinol-binding protein < 30 mg/l, 96·7 %; transferrin < 2000 mg/l, 80·6 %; TAG < 500 mg/l, 50 %; cholesterol < 1000 mg/l, 82·1 %.

The median EE was 204·2 kJ/kg per d (48·8 kcal/kg per d), and the median respiratory quotient was 0·74. EE lower than 167·4 kJ/kg per d (40 kcal/kg per d) was detected in 32·6 % of the children, and EE was over

Table 1. Clinical characteristics and biochemical and anthropometric nutritional parameters of the patients

(Median values and 25th (P25) and 75th (P75) percentiles)

	Median	P25–P75
Age (months)	7·5	3·8–25·8
Weight (kg)	6·6	4·7–10·8
Ht (cm)	70	62·3–109·5
PRISM (% mortality)	4·1	2·2–7·9
PIM2 (% mortality)	3·7	2·2–9·5
PELOD (% mortality)	0·1	0·1–1·3
Blood glucose (mg/l)	1140	890–1410
Total proteins (g/l)	53	49–58
Albumin (g/l)	34	30–36
Prealbumin (mg/l)	110	95–130
Retinol-binding protein (mg/l)	16	10–20
Transferrin (mg/l)	1480	1090–1920
TAG (mg/l)	485	360–765
Cholesterol (mg/l)	730	620–850
Urea (mg/l)	250	200–350
Creatinine (mg/l)	3	2–4
VO_2 (ml/min per kg)	6·8	5·2–8·4
CO_2 production (ml/min per kg)	4·8	3·9–6·5
Energy expenditure		
kcal/kg per d	48·8	35·4–60·5
kJ/kg per d	11·6	8·4–14·4
RQ	0·74	0·67–0·87
Nitrogen balance (g/kg per d)	−1·8	−2·5– −1·3

PRISM, Paediatric Risk Score of Mortality; PIM2, Revised Paediatric Index of Mortality; PELOD, Paediatric Logistic Organ Dysfunction; RQ, respiratory quotient.

251 kJ/kg (60 kcal/kg) in only 23·9 % of the children. EE per kg correlated with body weight (r 0·485, P=0·001) but not with body weight related to age. There was an inverse correlation between body weight and nitrogen balance (r −0·70, P=0·001). Weight and EE were not found to be correlated with any of the other biochemical parameters.

None of the patients presented a positive nitrogen balance at the time of starting nutrition. Intravenous albumin had been administered to 26·7 % of the patients in 24 h before the study. There were no significant differences in the serum albumin and total protein levels between the patients who received albumin (32 (SD 6) and 52 (SD 7) g/l, respectively) and those who did not (33 (SD 5) and 55 (SD 8) g/l, respectively), nor were there any differences in nitrogen balance between the two groups.

Table 2 shows a comparison between the underweight patients (P<10) and those with a normal weight. The comparison between the patients with weights below the third percentile and above the third percentile was similar (data not shown). No differences were detected between the two groups in the clinical state, in the severity scores, in EE or in the majority of biochemical measurements. The percentages of patients with EE below 167·4 kJ/kg per d (40 kcal/kg per d) or above 251 kJ/kg per d (60 kcal/kg per d) were similar in the two groups. However, patients with a normal weight had a significantly more negative nitrogen balance than those with underweight.

When comparing patients according to their EE (Table 3), it was found that children with EE below 167·4 kJ/kg per d (40 kcal/kg per d) were younger and had a lower body weight and height than children with higher EE; they also had a significantly lower respiratory quotient and a less negative nitrogen balance. There were no significant differences in the proportion of underweight children between the patients with EE below 167·4 kJ/kg per d (40 kcal/kg per d) (60 %) and those with EE more than 167·4 kJ/kg per d (40 kcal/kg per d) (58·1 %) (P=1). No other differences were found in the values of the biochemical parameters.

Children with an EE > 251 kJ/kg per d (60 kcal/kg per d) had a significantly higher age and weight than the other patients (Table 3). No differences were found in the values of the biochemical parameters, except for higher total protein and transferrin levels in the patients with higher EE.

There were no significant differences in EE or in the biochemical parameters on comparing the patients with a risk of mortality above or below 5 % according to the PRISM, the Revised Paediatric Index of Mortality and the Paediatric Logistic Organ Dysfunction scales (data not shown).

Table 4 shows a comparison between the patients admitted for postsurgical care and those with medical conditions. There were no differences in EE between the two groups. The percentage of postsurgical patients with weights below the third percentile (66·7 %) was

Table 2. Comparison between the patients with underweight (weight ≤ tenth percentile (P10)) and the patients with a normal weight (weight > P10)

(Median values and 25th (P25) and 75th (P75) percentiles)

	Underweight		Normal wt		
	Median	P25–P75	Median	P25–P75	*P*
Number of patients	33		13		
Age (months)	7	3–18·5	11	5–48	0·195
Wt (kg)	6·1	4·1–8	10	6·6–18·5	0·007
Ht (cm)	67	60–81·3	108	74·4–154·3	0·033
PRISM (% mortality)	4·1	2·3–7·9	3·8	1·4–8·5	0·518
PIM2 (% mortality)	5·7	2·4–9·6	2·4	1·2–9	0·156
PELOD (% mortality)	0·1	0·1–1·3	0·1	0·1–0·1	0·109
Blood glucose (mg/l)	1045	890–1540	1140	930–1280	0·841
Total proteins (g/l)	53	49–57	53	49–62	0·900
Albumin (g/l)	34	31–37	31	29–35	0·132
Prealbumin (mg/l)	110	100–135	110	80–130	0·673
Retinol-binding protein (mg/l)	19	11–20	13	10–15	0·031
Transferrin (mg/l)	1460	1090–1770	2065	1090–2433	0·067
TAG (mg/l)	550	360–830	390	288–465	0·036
Cholesterol (mg/l)	690	610–755	870	690–1160	0·039
Urea (mg/l)	260	195–380	250	200–335	0·831
Creatinine (mg/l)	3	2–3·8	3·0	2·3–4·3	0·534
VO_2 (ml/min per kg)	6·6	5·2–8·2	7·4	5–9·5	0·626
CO_2 production (ml/min per kg)	4·7	3·9–6·4	4·8	3·9–7·1	0·643
Energy expenditure					
kcal/kg per d	48·1	37·2–63·9	50·3	34·7–58·5	0·798
kJ/kg per d	11·5	8·9–15·2	12	8·3–13·9	
RQ	0·74	0·67–0·87	0·72	0·68–0·84	0·687
Nitrogen balance (g/kg per d)	−1·7	−2·3– − 1·2	−2·3	−4·1– − 1·2	0·234

PRISM, Paediatric Risk Score of Mortality; PIM2, Revised Paediatric Index of Mortality; PELOD, Paediatric Logistic Organ Dysfunction; RQ, respiratory quotient.

Table 3. Comparison between the patients with energy expenditure (EE) lower and higher than 167·4 kJ/kg (40 kcal/kg) and EE lower and higher than 251 kJ/kg (60 kcal/kg)
(Median values and 25th (P25) and 75th (P75) percentiles)

	EE								
	<9·5 kJ/kg per d (<40 kcal/kg per d)		>9·5 kJ/kg per d (>40 kcal/kg per d)			<14·3 kJ/kg per d (<60 kcal/kg per d)		>14·3 kJ/kg per d (>60 kcal/kg per d)		
	Median	P25–P75	Median	P25–P75	*P*	Median	P25–P75	Median	P25–P75	*P*
Number of patients	15 (32·6 %)		31 (67·4 %)			35 (76·1 %)		11 (23·9 %)		
Age (months)	3·0	1·3–5·0	12·0	6–48	0·001	6·0	3·0–120	24	7–132	0·043
Wt (kg)	4·8	3·5–6·5	7·8	6·2–18	0·001	6·4	4·1–7·8	9·2	6·6–27	0·014
Wt/mean of wt for age and sex	0·6	0·4–3·3	0·4	0·3–1·9	0·079	0·5	0·4–2·4	0·4	0·3–1·9	0·261
Ht (cm)	59·5	51·0–68·2	90·2	66–144·5	0·009	66·0	56·0–96·6	89·5	67·3–135	0·157
PRISM (% mortality)	4·1	2·3–8·9	4·2	1·7–7·5	0·630	4·1	2·2–9·4	4·1	1·8–6	0·558
PIM2 (% mortality)	4·4	2·6–9·6	3·2	1·7–9·3	0·159	4·1	2·4–9·5	2·9	1·7–11·5	0·886
PELOD (% mortality)	0·1	0·1–1·3	0·1	0·1–1·3	0·941	0·1	0·1–1·3	0·1	0·1–0·1	0·382
Blood glucose (mg/l)	980	810–1175	1220	950–1660	0·059	1045	888–1345	125	930–1660	0·367
Total proteins (g/l)	50	48–55	54	50–62	0·059	53	48–56	57	52–67	0·015
Albumin (g/l)	31	27–36	34	31–36	0·063	34	30–36	34	31–37	0·473
Prealbumin (mg/l)	100	78–113	120	103–138	0·055	110	80–130	120	105–145	0·397
Retinol-binding protein (mg/l)	2	11–23	1·5	1–2	0·397	15	10–20	17	11–19	0·824
Transferrin (mg/l)	1280	1068–1575	1570	1160–2050	0·145	1420	940–1780	1850	1605–2612	0·009
TAG (mg/l)	640	380–870	440	360–670	0·120	545	333–830	410	360–573	0·233
Cholesterol (mg/l)	630	580–760	730	635–1000	0·142	730	595–910	690	6350–8550	0·912
Urea (mg/l)	245	205–343	270	190–360	0·932	245	188–353	270	210–350	0·785
Creatinine (mg/l)	2·8	2·0–3·8	3·0	2·0–4·0	0·479	3·0	2·0–3·9	3·0	2·9–6·0	0·176
VO_2 (ml/min per kg)	5·1	4·1–5·8	7·9	6·2–9	0·001	5·9	4·5–7·4	9·2	8·2–14	0·001
CO_2 production (ml/min per kg)	3·9	3·6–4·7	5·1	4·4–7·6	0·003	4·5	3·9–5·7	7·6	5–9·9	0·001
RQ	0·82	0·69–0·95	0·72	0·67–0·76	0·026	0·76	0·68–0·87	0·70	0·66–0·75	0·183
Nitrogen balance (g/kg per d)	−1·5	−1·8– − 0·8	−2·3	−3·3– − 1·4	0·045	−1·8	−2·6– − 1·3	−1·6	−2·5– − 0·9	0·445

PRISM, Paediatric Risk Score of Mortality; PIM2, Revised Paediatric Index of Mortality; PELOD, Paediatric Logistic Organ Dysfunction; RQ, respiratory quotient.

Table 4. Comparison between the patients admitted for postsurgical care and those admitted for medical conditions

(Median values and 25th (P25) and 75th (P75) percentiles)

	Surgical		Medical		
	Median	P25–P75	Median	P25–P75	*P*
Number of patients	36		10		
Age (months)	8	4–23·8	6	2·6–99	0·948
Wt (kg)	6·5	4·6–9·2	6·8	4·5–24·6	0·609
PRISM (% mortality)	3·3	2·1–7·2	6·2	4·1–18·3	0·076
PIM2 (% mortality)	3·6	2·2–9·4	8·7	2·0–13	0·334
PELOD (% mortality)	0·1	0·1–0·8	1	0·1–1·3	0·190
Blood glucose (mg/l)	1140	890–1445	990	895–1555	0·878
Total proteins (g/l)	54	50–58	50	45–59	0·320
Albumin (g/l)	34	31–37	30	24–35	0·033
Prealbumin (mg/l)	120	100–138	95	55–110	0·026
Retinol-binding protein (mg/l)	18	11–20	11	10–14	0·025
Transferrin (mg/l)	1475	1083–1883	1780	1000–2435	0·480
TAG (mg/l)	540	360–770	410	325–645	0·337
Cholesterol (mg/l)	730	620–840	745	423–865	0·959
Urea (mg/l)	260	210–350	250	145–395	0·606
Creatinine (mg/l)	3·0	2·0–3·9	3·0	2·4–7·7	0·348
VO_2 (ml/min per kg)	6·8	5·2–8·2	6·8	4·1–8·8	0·969
CO_2 production (ml/min per kg)	4·6	3·9–7·3	4·9	3·9–6·1	0·844
Energy expenditure					
kcal/kg per d	49·2	36·7–66·1	44·8	28·4–54·6	
kJ/kg per d	11·7	8·7–15·8	10·7	6·8–13	0·454
RQ	0·75	0·71–0·82	0·81	0·72–0·93	0·364
Nitrogen balance (g/kg per d)	−1·8	−2·5– −1·3	−1·1	−2·2– −0·5	0·976

PRISM, Paediatric Risk Score of Mortality; PIM2, Revised Paediatric Index of Mortality; PELOD, Paediatric Logistic Organ Dysfunction; RQ, respiratory quotient.

significantly higher than among patients with medical conditions (30 %) (P=0·037). However, children with medical conditions presented significantly lower levels of albumin, prealbumin and retinol-binding protein than the postsurgical patients. There were no differences between the two groups in the other biochemical parameters studied.

A comparison between the children with heart disease and those with other conditions is presented in Table 5. There were no differences between the two groups with regard to EE, anthropometric status or the majority of biochemical parameters.

Discussion

The present study shows that a large percentage of children who are admitted to intensive care units present underweight and lower levels of protein biochemical parameters. Our data coincide with the findings in other series in children[1–5]. In the present study, there were no significant differences in the majority of biochemical parameters between patients with underweight and those with a normal weight. Other authors have also found no significant association between abnormalities in the biochemical parameters and the anthropometric measurements in critically ill children[25].

Critically ill children suffer intense metabolic stress, and, in addition, they are in a growth and development phase. Inadequate nutritional support can have a negative impact on their vital prognosis and on recovery from disease.

Various studies in critically ill children have shown that the concordance between EE measured by indirect calorimetry and the value estimated by formulas is not good[6–8,12–18], leading to a high incidence of underfeeding or overfeeding[6,16,17]. This is because the majority of these formulas are based almost exclusively on weight and height, and in some cases they have not been designed for or validated in children, and, in particular, they do not take into account other factors that could affect EE, such as the type and severity of the disease[6,9,10,16,19].

The present study is the first to have analysed whether there is a relationship between EE and the state of clinical severity measured using three mortality risk indices and anthropometric or biochemical nutritional status in critically ill children. The mean EE in our patients was similar to that found in other series of critically ill children, with a very broad range, indicating the presence of a wide inter-individual variability[6–8,12–18].

In the present study, we found no relationship between EE at the time of starting nutrition and the anthropometric and biochemical evaluation of the nutritional status, or with clinical severity measured using the PRISM, the Revised Paediatric Index of Mortality and the Paediatric Logistic Organ Dysfunction scales. The most seriously ill children did not have higher EE or higher percentage of underweight or biochemical protein alterations. Other authors have also been unable to find any relationship between the PRISM score and EE[8].

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Table 5. Comparison between the children with heart disease and other patients (Median values and 25th (P25) and 75th (P75) percentiles)

	Heart disease		Other diagnoses		
	Median	P25–P75	Median	P25–P75	*P*
Number of patients	33		13		
Age (months)	11	4·5–47·5	7	3–23·5	0·766
Wt (kg)	7	4·1–16·5	6·5	5–9	0·313
PRISM (% mortality)	4·1	1·5–13·3	4·2	2·3–7·5	0·084
PIM2 (% mortality)	2·4	1·1–8	5·1	2·4–9·6	0·022
PELOD (% mortality)	0·1	0·1–1·2	0·1	0·1–1·3	0·494
Blood glucose (mg/l)	1000	873–1255	1180	910–1570	0·152
Total proteins (g/l)	52	46–59·9	53	50–58	0·397
Albumin (g/l)	34	29–36	33	31–37	0·740
Prealbumin (mg/l)	120	110–135	110	80–130	0·346
Retinol-binding protein (mg/l)	15	11–19	17	10–20	0·806
Transferrin (mg/l)	1870	1320–2300	1450	1030–1773	0·078
TAG (mg/l)	360	280–440	550	400–800	0·002
Cholesterol (mg/l)	870	720–1240	690	613–765	0·193
Urea (mg/l)	210	125–295	290	215–370	0·049
Creatinine (mg/l)	2·3	2·0–3·0	3·0	2·4–4·0	0·003
VO_2 (ml/min per kg)	6·2	3·9–8·7	7·0	5·3–8·3	0·524
CO_2 production (ml/min per kg)	5·1	4·2–6·6	4·5	3·9–6·9	0·386
Energy expenditure					
kcal/kg per d	49·0	36·2–54·7	48·2	34·8–70·4	
kJ/kg per d	11·7	8·6–13	11·5	8·3–16·8	0·581
RQ	0·74	0·67–0·80	0·77	0·69–0·93	0·524
Nitrogen balance (g/kg per d)	−1·8	−2·3– −1·3	−2·5	−4·3–0·7	0·354

PRISM, Paediatric Risk Score of Mortality; PIM2, Revised Paediatric Index of Mortality; PELOD, Paediatric Logistic Organ Dysfunction; RQ, respiratory quotient.

Some studies have reported that patients with sepsis have higher EE than surgical patients[7]. In the present study, we found no relationship between EE and the type of patient, medical or surgical. Children with underweight did not have higher EE than those with a normal weight.

Indirect calorimetry is the best tool for controlling nutrition in critically ill paediatric patients, as it enables EE to be calculated simply and quickly in each patient. The majority of studies of indirect calorimetry have used a specific instrument (Deltatract® Datex-Ohmeda, Helsinki, Finland) that requires a considerable economic outlay[7–9,12,17,18]. In the present study, we used a new measuring device that is simpler and cheaper and that connects to a multiparameter monitor. This device shows a good correlation with the Deltatract[6,26–29]; its drawback is that calorimetry can only be performed in patients on mechanical ventilation[6,27].

The present study has certain limitations. The sample size was relatively small, and a large percentage of the patients were surgical, reducing the power of the statistical comparisons between the different diagnostic groups. The study population has a broad, but skewed, age range. About 75 % of the children were 2 years of age or younger. This fact could make more difficult the analysis and interpretation of the data. However, this is the representation of the real population of our PICU, and we think of most of the PICU in the world. Furthermore, the objective of the study was to assess the relationship between the initial state of the patients and their energy requirements at the time of starting nutrition, and we therefore did not study the changes in EE in these patients. However, some studies have found that there are no significant variations in EE over the course of a patient's admission to intensive care[7].

We only used weight as the anthropometric measure of nutrition status because, in critically ill patients, acute malnutrition is the more frequent and important kind of malnutrition. Moreover, in these patients, it is not always possible to measure the height.

We conclude that, in critically ill children, there is no correlation between EE and anthropometric and biochemical nutritional status or clinical severity. Thus, neither the nutritional status, evaluated using anthropometric (weight) or protein biochemical measurements, nor the clinical severity on admission will help to determine the energy delivery that a critically ill child requires. It is therefore necessary to measure EE individually using indirect calorimetry in each critically ill child.

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