Substrate Utilization in Ventilated Critically Ill Children: A Longitudinal Study

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Adequate nutritional support: decreased mortality and morbidity (Mehta 2012).

Nutritional needs are difficult to determine: effect of treatments, fever, metabolic stress, etc.

Energy needs have been documented, but the needs in macronutrients (protein, lipids and carbohydrates) during the stay remains unknown.

The recommendations are vague.
The aim of this study was to determine:

- macronutrients utilization and
- macronutrients balances

during the first week of hospitalization in ventilated critically ill children.
Method

- Observational study in the Paediatric Intensive Care Unit of the CHUV.

- Children with expected mechanical ventilation ≥72 hours and a FiO₂ ≤60% were consecutively included.

- Measurements of indirect calorimetry and urinary nitrogen daily:
  - Energy expenditure (kcal/d): 5.50VO₂ + 1.76VCO₂ – 1.99N
  - Proteins utilization (g/d): 6.25N
  - Lipids utilization (g/d): 1.67 (VO₂-VCO₂) – 1.92N
  - Carbohydrates utilization (g/d): 4.55VCO₂ – 3.21VO₂ – 2.87N

- Balances: difference between intake and utilization
### Patients characteristics

| Characteristic                      | Value
|------------------------------------|--------
| n (girls/boys)                     | 63 (29/34) |
| n (measures)                       | 343     |
| Age (months)                       | 21 (0.1-103) |
| Weight (kg)                        | 10 ± 5  |
| Prism score (day 1)                | 6 ± 4   |
| Length of stay (days)              | 13 ± 10 |
| Enteral nutrition (n)              | 58 (92%)|

Mean ± SD
Energy intake, energy expenditure and balance

![Graph showing energy intake, expenditure, and balance over 7 days.](image)

- **Energy intake** (black bars)
- **Energy expenditure** (blue line)
- **Energy balance** (teal line)

**Legend**
- Purple line: Energy expenditure
- Black bars: Energy intake
- Teal bars: Energy balance

**Axes**
- X-axis: Days (23, 54, 55, 51, 42, 33, 23)
- Y-axis: Energy (kcal/kg/d)

**Data**
- **n = 63**
- **Mean ± SD**

**Table**
- Days:
  - 23
  - 54
  - 55
  - 51
  - 42
  - 33
  - 23

**Energy Intake**:
- Days 1 to 4: 60 kcal/kg/d
- Days 5 to 7: 20 kcal/kg/d

**Energy Expenditure**:
- Days 1 to 4: 60 kcal/kg/d
- Days 5 to 7: 20 kcal/kg/d

**Energy Balance**:
- Days 1 to 4: 40 kcal/kg/d
- Days 5 to 7: 0 kcal/kg/d

**Summary**
- Energy intake and expenditure are balanced from days 5 to 7.
- Days 1 to 4 show a higher energy intake compared to expenditure.
Macronutrients intakes, utilization and balances: entire stay

<table>
<thead>
<tr>
<th></th>
<th>Intake</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g/kg/d)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lipids (g/kg/d)</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Carbohydrates (g/kg/d)</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

n = 63
Mean ± SD
Daily evolution

Utilization

Intake

Balance

Lipids (g/kg/d)

Carbohydrates (g/kg/d)

Protein (g/kg/d)
Respiratory quotient and quotient of food

Respiratory quotient = 0.81 ± 0.06
Quotient of food = 0.92 ± 0.05
Conclusion

During the first week of hospitalization, we observed in ventilated critically ill children:

- A slight negative energy balance
- A good oxidation of lipids and proteins
- But an insufficient carbohydrate oxidation compared to carbohydrate intakes
  - probably due to a reduced oxidation capacity and insulin resistance in metabolic stress conditions.
  - although intake was not excessive (6.8 g/kg/d = 4.7 mg/kg/min)
- Consequently, measured RQ was lower than RQ from intakes
Take home message

In clinical practice:

- Energy expenditure should be measured to avoid under- and overfeeding.
- Carbohydrates intake should be carefully managed and glucose from perfusion considered.
- Lipids intake must be sufficient.
THANK YOU
Glucose: ESPGHAN, 2005

- Glucose administration to full term neonates and children up to 2 years of age should not exceed 15 to 18 g/kg/d (10 to 13 mg/kg/min). GOR C

- In critically ill children glucose intake should be limited to 5 mg/kg/min (7.2 g/kg/d). GOR D

- Glucose intake should be adapted in case of simultaneous administration of drugs known to impair glucose metabolism such as steroids, somatostatin analogs, tacrolimus. GOR C

- Variations in glucose intake according to age and clinical situation (e.g. malnutrition, acute illness, drug administration) should be considered. GOR D
To be considered according to:
- clinical situations ie: risk of refeeding syndrome, sepsis, drugs
- required weight gain for normal or catch up growth
- total energy intake including oral and/or enteral delivery
Glucose and energy

- Intake glucose
  - 2 mg/kg/min = 11 kcal/kg/dy
  - 4 mg/kg/min = 22 kcal/kg/dy
  - 6 mg/kg/min = 33 kcal/kg/dag
  - 8 mg/kg/min = 44 kcal/kg/dag

- Child 10 kg = REE 45 kcal/kg/dag
  - = 25% REE
  - = 50% REE
  - = 75% REE
  - = 100% REE

Adapted from Joosten K, 2012
Macronutrients utilization / Energy expenditure
Macronutrients utilization / Energy expenditure

**Energy expenditure**
- Proteins: 10%
- Carbohydrates: 38%
- Lipids: 52%

**Energy intake**
- Proteins: 10%
- Carbohydrates: 60%
- Lipids: 27%

**Mother's milk**
- Proteins: 6%
- Carbohydrates: 41%
- Lipids: 53%
Macronutrients utilization / Energy expenditure

Group

- apports prot/AET (kcal/j)
- apports Lip/AET (kcal/j)
- apports Gluc/AET (kcal/j)

Days after admission

%
Respiratory quotient and food quotient

![Graph showing respiratory quotient and food quotient over days after admission.](image-url)
Protein intakes, utilization and balances by age group

[Bar charts showing protein intake, losses, and balance for different age groups]
Carbohydrate intakes, utilization and balances by age group

- Carbohydrate intake (g/kg/d)
  - 0-6 months
  - 7-12 months
  - 1-3 years
  - 4-8 years

- Carbohydrates utilization (g/kg/d)
  - 0-6 months
  - 7-12 months
  - 1-3 years
  - 4-8 years

- Carbohydrates balance (g/kg/d)
  - 0-6 months
  - 7-12 months
  - 1-3 years
  - 4-8 years
Lipids intakes, utilization and balances by age group

- Lipids intake (g/kg/d)
- Lipids utilization (g/kg/d)
- Lipids balance (g/kg/d)
Respiratory quotient (RQ) and food quotient (FQ)