The Resting Energy Expenditure and Utilization of Nutritive Substrates in Polytrauma Patients in the ICU

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Rationale

Indirect calorimetry (IC) is the gold standard for measuring resting energy expenditure (REE) in the critically ill patient. REE determination is of high relevance to avoid both overfeeding and underfeeding, both of which increase morbidity and mortality rate. Multiple traumas cause an increase in plasma concentrations of pro-inflammatory cytokines, regulatory cytokines and cortisol and a decrease in concentration of anti-inflammatory cytokines. These changes lead to increased metabolic rate, protein catabolism and vascular permeability with edema. The aim of this study was to determine the resting energy expenditure and utilization of nutritive substrates (UNS) in polytrauma patients compared with healthy volunteers that is not well known.

Study design

This single-center pilot study was performed on 16 polytrauma patients (PP) (14 men and 2 women) with mean age 38.6±16.3 years and compare with 24 healthy subjects (HS) (10 men and 14 women) with mean age 36.7±15.7 years, both was obtained after 12 hours of fasting prior to assessment. PP were spontaneously breathing in the intensive care unit, and all had high mean APACHE II and ISS scores. The study was reviewed and approved by the Ethical Committee of Charles University, Faculty of Medicine in Hradec Kralove and all subjects gave written informed consent.

Statistical analysis

The acquired data were analyzed using programs Graph-Pad Prism6 (GraphPad Software, La Jolla, CA, USA) and Excel 2013 (Microsoft, Redmont, WA, USA). All parameters were evaluated by descriptive statistics. Values are expressed as mean ± SD. Statistically significant differences between parameters were evaluated by the Student t test.

Methods

Measurement of resting energy expenditure (in kcal/day) together with nutritional substrates utilization (in g/kg/day) was carried out using an indirect calorimeter (IC) with a ventilated hood system (Vmax Series, V6200 Autobox, SensorMedics Corporation, California, USA). REE was obtained after 12 hours of fasting prior to assessment. Subjects were at rest for 30 minutes before the assessment. IC measures the difference between inspired and expired volumes of oxygen and carbon dioxide; the determinants VO_2 and VCO_2 were obtained over a 30-min period. Calibration was carried out before each examination according to standard procedures for the machine. The ambient temperature was set at 23 °C and relative humidity was 60 – 80 %. Subjects were in a relaxed, supine position either under the canopy hood or with special equipment for ventilation.

Using the recorded values of oxygen consumption (in l/min), carbon dioxide production (in l/min), and total urinary nitrogen excretion (in g/day) were then converted to REE and UNS with standard manufacturer's computer programs (Vmax Series) according to the Weir equation which applies a correction for nitrogen expenditure (NE). NE was calculated as the sum of urinary urea nitrogen (UN in g/day) and non-urea nitrogen from faeces, skin and miscellaneous, predicted from weight (W in kg) according equation: **NE = UN + 0.03 * W**.

24 h urine samples were collected for laboratory measurements of UN, which was determined by a standard kinetic UV assay (Roche/Hitachi 917 analyser) at University Hospital (Roche Diagnostics).

The basal metabolic rate (BMR) used in the manufacturer's software as a metabolic characteristic of a healthy subject for comparison with the measured REE, was calculated by the Harris-Benedict equation. The ratio REE/BMR as a percentage was used for expression of the metabolic state, and was classified according to the following criteria: hypometabolism, less than 90%; normometabolism, between 90% and 110%; and hypermetabolism, greater than 110%.

Results

	PP (n = 16)	HS (n = 24)
Age [years]	38.6 ± 16.4	36.2 ± 16.4
Height [m]	177.9 ± 9.2	174.6 ± 7.4
Body weight [kg]	88.5 ± 19.4 *	72.0 ± 16.2
BMI [kg/m^2]	27.9 ± 7.5 *	23.5 ± 4.3
Length of ICU stay [d]	9.0 ± 9.9	-
BSA [m^2]	2.1 ± 0.2	1.9 ± 0.2
UN [g/d]	30.0 ± 13.0 *	14.4 ± 5.4
ISS score	28.0 ± 9.2	-
APACHE II score	9.6 ± 6.3	-

Table 1. Demographic and descriptive characteristics of the patients

Values given are the mean ± SD; *— statistically significant difference between PP and HS (*P<0.05*)

Abbreviations: BMI— body mass index; BSA— body surface area; UN — urine nitrogen excretion;

2A	PP (n = 16)	HS (n = 24)
VO_2 [l/min]	0.36 ± 0.08 *	0.25 ± 0.05
VCO_2 [l/min]	0.25 ± 0.06 *	0.19 ± 0.05
RQ	0.70 ± 0.08*	0.76 ± 0.06
NRQ	0.67 ± 0.16*	0.72 ± 0.13
REE [kcal/d]	2,394 ± 554 *	1,695 ± 338
BMR [kcal/d]	1,935 ± 256 *	1,634 ± 228
REE/BMR [%]	123 ± 26 *	106 ± 12
REE/W [kcal/kg/d]	27.1 ± 7.7	23.5 ± 3.3
REE/BSA [kcal/m^2/d]	1,140 ± 256 *	914 ± 108

2B	PP (n = 16)	HS (n = 24)
Carbohydrate utilization [g/kg/d]	1.5 ± 1.2	1.2 ± 1.6
Carbohydrate utilization [% TCEE]	33.8 ± 14.6	22.5 ± 16.8
Lipid utilization [g/kg/d]	1.6 ± 0.6	1.5 ± 0.5
Lipid utilization [% TCEE]	53.9 ± 19.2	58.4 ± 16.9
Protein utilization [g/kg/d]	2.1 ± 1.0 *	1.2 ± 0.4
Protein utilization [% TCEE]	33.8 ± 10.6	22.5 ± 7.1

Table 2. Parameters from indirect calorimetry measurements: 2A—Energy expenditure; 2B—Nutrition substrate utilization

Values given are the mean ± SD; *— statistical significance difference between PP and HS (*P<0.05*)

Abbreviations: VO_2 [l/min]— oxygen consumption; VCO_2 [l/min]— carbon dioxide expiration; RQ— respiratory quotient; NRQ— non-protein respiratory quotient; REE [kcal/d]— resting energy expenditure; BMR— basal metabolic rate predicted via Harris-Benedict equation; REE/BMR [%] — % energy expenditure of Harris-Benedict equation; REE/W — energy expenditure per kg body weight; REE/BSA— energy expenditure per m^2 body surface area; TCEE — total caloric energy expenditure

- **Patient REE** was as expected **significantly higher** than that of the control group, corresponding to the hypermetabolism, typical for polytrauma patients. 68.6% of PP were in a hypermetabolic state (29.2% in HS), 25.0% were in a normometabolic state (58.3% in HS), and 6.3% were in a hypometabolic state (12.5% in CG).
- PP had **higher REE expressed in kcal/d** compared with HS (1,935.0±256.0 kcal/d vs. 1,634.0±228.0 kcal/d; *P<0.01*), but both groups had **similar REE expressed per kg body weight**: PP 27.1±7.7 kcal/kg/d; and HS 23.5±3.3 kcal/kg/d (*P=0.30*).
- PP had **higher utilization of protein** (2.1±1.0 g/kg/d vs. 1.2±1.6 g/kg/d; *P<0.01*), **similar carbohydrate** (1.5±1.2 g/kg/d vs. 1.2±1.6 g/kg/d; *P=0.62*) and **lipid utilization** (1.6±0.6 g/kg/d vs. 1.5±0.5 g/kg/d; *P=0.70*) compared with healthy subjects.

Conclusion

REE expressed in 27 kcal/kg/d in PP was similar to that in healthy individuals. Precisely measured body weight was demonstrated as determinant of REE and UNS in PP. Protein oxidation in PP was increased in 2 g/kg/d relative to healthy subjects. Validation study will follow to demonstrate that fact, which could then be applied in clinical practice for predicting REE.

There are no financial conflicts of interest for any author. Supported by MH CZ— DRO [UHHK, 00179906]; Charles University in Prague [17/2012/UNCE]; PRVOUK P40 and Faculty of Pharmacy [SVV 267 003].