Original Article

Comparison between measured and predicted resting energy expenditure in mechanically ventilated patients with COPD

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The aim of this study was to compare resting energy expenditure (REE) obtained by indirect calorimetry (IC) and Harris-Benedict (H-B) equations, and to examine whether hypocaloric nutrition support could improve protein nutritional status in mechanically ventilated patients with chronic obstructive pulmonary disease (COPD). Thirty-three COPD patients (20 males, 13 females) were recruited and REE was measured by IC. Measured REE (REEm) was compared to predictive REE by H-B equations (REE_{H-B}) and its corrected values. Correlation between REEm and APACHE II score was also analyzed. Patients were randomly divided into hypocaloric energy group (50%-90% of REEm, En-low) and general energy group (90%-130% of REEm, En-gen) for nutrition support. The differences of albumin, prealbumin, transferrin, hemoglobin, and lymphocyte count before and after 7 days nutrition support were observed. Results show that REE_{H-B} and $REE_{H-B}\times1.2$ were significantly lower than REEm ($p<0.01$). REEm positively correlated with APACHE II score ($p<0.05$ or $p<0.01$). After nutrition support, hemoglobin decreased significantly in En-gen group ($p<0.05$); lymphocyte count in both groups, and transferrin and prealbumin in the En-low group increased significantly ($p<0.05$ or $p<0.01$). Our data suggest that 1) these patients' REE were increased; 2) since IC is the best method to determine REE, in the absence of IC, H-B equations (with standard body weight) can be used to calculate REE, but the value should be adjusted by correction coefficients derived from APACHE II; 3) low energy nutrition support during mechanical ventilation in COPD patients might have better effects on improving protein nutritional status than high energy support.

Key Words: resting energy expenditure, indirect calorimetry, mechanical ventilation, APACHE II score, predictive equation for energy expenditure

INTRODUCTION

The metabolism of mechanically ventilated patients with chronic obstructive pulmonary disease (COPD) changes because of increased stress. These changes include increased catabolism, decreased anabolism, and compromised immune functions. Metabolism changes could cause malnutrition and difficult weaning from mechanical ventilation, if insufficient intakes of energy and protein are also present. Individuals adjust their metabolism in response to stress differently. The change of energy expenditure might be different among patients at the same stress level,[1] and energy expenditure in the same patient is also different at different stages of disease. Total energy supplement becomes the focus of nutrition therapy in order to prevent malnutrition in these patients. In the clinical setting, the total energy requirement is often estimate based on REE calculated by predictive equations, among them, Harris-Benedict (H-B) equations is the most commonly used one. However, this equation is inaccurate in estimating REE in individuals, especially in mechanically ventilated critically ill patients.[2-5] Thus, indirect calorimetry (IC) has also been used to determine REE.

In this study, we first used IC to measure REE in mechanically ventilated COPD patients, and then we investigated possible factors that can increase the accuracy of predicted REE. We also explored how to improve the accuracy of REE estimated by H-B equations because IC is not available everywhere. We also designed nutritional support regimen based on measured REE and observed how the indicators of nutritional status in these patients would change after the treatment.

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SUBJECTS AND METHODS

Subjects

Thirty-three (20 males and 13 females) mechanically ventilated patients with COPD from RICU of West China hospital, Sichuan University, were recruited. The mean age was 74.8±8.7 (range 51-90 years old).

Inclusion criteria

1) COPD diagnosis confirmed by worldwide guidelines for chronic obstructive pulmonary disease;[6] 2) on mechanical ventilation for more than 7 days; 3) tolerating total or partial enteric nutrition support well.

Exclusion criteria

Patients with pulmonary tuberculosis, bronchial asthma, pneumothorax, diabetes, malignant tumor, hyperthyroidism, severe hepatic or renal dysfunction, hypertension, neuromuscular diseases were excluded from the study. Patients with following conditions were also excluded:[3]

a) Hemodynamic instability: initiating, adjusting dose, and withdrawing inotropic drugs (catecholamines, β_2-mimetic, and theophylline) within 2 hours of REE measurement.
b) Respiratory instability: pulse oxygen saturation <90%, modification of ventilator settings within 2 hours of REE measurement, signs of hyperventilation (respiratory rate >35/min), presentation of respiratory weakness during positive pressure ventilation.
c) Alteration in carbon dioxide pool: bicarbonate infusion, intestinal/renal loss of bicarbonate (diarrhea, ureterosigmoidostomy, acetazolamide application), extracorporeal circulation for dialysis.
d) Intravenous carbohydrate load >15 kcal/kg·d (ie, 5000 ml of 5% dextrose/d).
e) Air leaking around the respiratory circuit (aerosolization, lines for nitric oxide or heliox, and tracheal gas insufflation), or visible air leaking in the chest-drainage system.
f) Accumulation of intermediate metabolites in vivo (such as pyruvic acid, lactic acid and so on), ketoacidosis, or alcoholic intoxication.

Measurement and calculation of REE

Instrument

REE was measured (REEm) in a thermo neutral environment by open circuit indirect calorimetry (metabolic cart) machine (Ultima PFX system, SN: 218000305, Model: 790705-205, Medical Graphics Corp., USA) that was connected directly to tracheal cannula.

Metabolic cart settings and measuring requirements

The metabolic cart was preheated for 30 minutes. Gas and flow were calibrated before measurement. The tracheal cannula and ventilating machine's tube were connected to the flow sensor of the metabolic cart so the inspired and expired gases all pass through the sensor. Other requirements were as follows:[7]

a) Patients were rested in a supine position (in bed) for more than 30 minutes before the study to avoid the effects of voluntary activity on REE.
b) Patients on intermittent feedings (bolus enteral feeding, cyclic enteral feeding, or parenteral nutrition) were studied approximately 12 hours after the last feeding because thermogenesis can affect the measurement of REE.
c) For patients receiving continuous feeding, the rate and composition of nutrients infusion were stable for at least 12 hours before and through the study.
d) The study would be delayed 1 hour if painful procedures had been performed.
e) Routine nursing care or other health care activities were avoided during the study.
f) The fraction of inspired oxygen (FiO_2) remained constant during the measurement.
g) The study would be delayed for 90 minutes if changes were required in ventilator settings.
h) Respiratory rates lower than 35 per minute and pulse oxygen saturation >90% were necessary for accurate measurements.[3,8]
i) One of the most important requirements is that the metabolic cart system must be in a steady state in order to obtain reliable VO_2 and VCO_2 values. A steady state in the IC technique is usually defined as a single 5-minute interval during which the average change of VO_2 and VCO_2 are less than 10%/minute, and the variation coefficients ($S/\overline{X}$) of both VO_2 and VCO_2 are less than 5%.[9-12] The measurement time was 30 minutes. Fluctuation data must be deleted for reliable prediction.[13]

Measurements of REE

The study lasted 7 days. REEm was obtained by IC on the first day and the 7th day, and the test time was between 8:30AM and 11:00AM. REE, RQ, energy from lipid metabolism (M_{Lip}), and energy from carbohydrate metabolism (M_{CHO}) were calculated.

$$REE=3.941\times VO_2+1.106\times VCO_2$$ [14]

$$RQ= VCO_2/ VO_2$$

$$M_{CHO}=4.12\times VO_2-2.91\times VCO_2$$ [14]

$$M_{Lip}=1.81\times(VO_2-VCO_2)$$ [14]

Predictive REE and its accuracy

Age, gender and body height (H) were recorded. Broca formula [BWs=H (cm)-105] for males and Broca revise formula [BWs=H (cm)-100] for females were used to calculate standard body weight (BWs).[15] REE was estimated by H-B equations using BWs (REE_{H-B}) ,[16] and then was adjusted by multiplying coefficient 1.2 and 1.5.[17,18] H-B equations in males: REE (kcal) = 66.47 + 13.75×BW (kg) + 5.0×H (cm) - 6.76×Age (y), in females: REE (kcal) = 655.51 + 9.56×W (kg) + 1.85×H (cm) - 4.68×Age (y).[19]

REE_{H-B} was compared with REEm to determine its accuracy. REE_{H-B} that was within ±10% of REEm was defined as accurate, while above 10% and below 10% of REEm were defined as overestimated and underestimated, respectively. [20, 21]

APACHE Ⅱ (Acute Physiology and Chronic Health Evaluation II) score

APACHE II scores were recorded simultaneously with REE measurements. Table 1 shows the parameters and grading system used in the calculation of APACHE II scores.

Table 1. Parameters and grading system of APACHE II Scores

Parameter	Score value				
	0	1	2	3	4
T (℃)	36.0-38.4	34.0-35.9 or 38.5-38.9	32.0-33.9	30.0-31.9 or 39.0-40.9	≤29.9 or ≥41.0
MAP (kPa)	9.3-14.5	—	6.7-9.2 or 14.7-17.2	17.3-21.2	≤6.5 or ≥21.3
HR (min^{-1})	70-109	—	56-69 or 110-139	40-54 or 140-179	≤39 or ≥180
RR(min^{-1})	12-24	10-11 or 25-34	6-9	35-49	≤5or ≥50
PaO_2 (kPa)	>9.33	8.13-9.33	8.00-8.13	7.33-8.00	<7.33
pH Value	7.33-7.49	7.50-7.59	7.25-7.32	7.15-7.24 or 7.60-7.69	<7.15 or ≥7.70
Na (mmol/L)	130-149	150-154	120-129 or 155-159	111-119 or 160-179	≤110 or ≥180
K (mmol/L)	3.5-5.4	3.0-3.4 or 5.5-5.9	2.5-2.9	6.0-6.9	<2.5 or ≥7.0
Scr (μmol/L)	53.0-123.8	—	<53.0 or 132.6-168.0	176.8-300.6	≥309.4
Hct (%)	30.0-45.9	46.0-49.9	20.0-29.9 or 50.0-59.9	—	<20.0 or ≥60.0

T, body temperature; MAP, mean arterial pressure; HR, heart rate; RR, respiration rate; PaO_2, partial pressure of oxygen in artery; Na, concentration of serum sodium; K, concentration of serum potassium; Scr, serum creatinine; Hct, haematocrit.

Table 2. Comparison of $REE_{H\text{-}B}$ and its corrected values with REEm in mechanically ventilated patients with COPD (mean±SD, kcal/d)

Methods†	REE(kcal/d)					
	Males (*n*=35)	*p* value	Females (*n*=25)	*p* value	Total (*n*=60)	*p* value
REEm	1897±374	—	1520±292	—	1740±388	—
H-B	1249±117	0.000	1111±66	0.000	1196±118	0.000
H-B×1.2	1498±141	0.000	1333±79	0.004	1435±142	0.000
H-B×1.5	1873±176	0.711	1683±106†	0.006	1794±177	0.238

†REE, resting energy expenditure; REEm, measured REE; H-B, Harris-Benedict equations.

Assignments of Patients to Different Nutritional Support Regimens

Patients assignments and nutrition treatment plans

According to the first measurement of REE, the patients were randomly (with "RAND" function in Microsoft Excel) divided into general energy group (En-gen group) and low energy group (En-low group). The energy supplement of patients in En-gen group was within 90%-130% of the 1st measurement of REE, while that of En-low group was within 50%-90% of the 1st measurement of REE.[22] The percentages of energy provided by three major nutrients in enteral nutrition support were: fat 20%-30%, carbohydrate 55%-60%, and protein 12%-18%. If the energy from enteral nutrition support cannot meet the requirement, then parenteral nutrition support would be employed. But the percentage of energy from fat would not exceed 40% during the 7 days' observation.

Observation parameters

Blood was collected on the 1st and the 7th day. Plasma albumin (Alb), transferrin (Tf), prealbumin (PA), hemoglobin (Hb), and total lymphocyte count (TLC) were measured to determine the effects of nutritional support. Patients' heart rate, respiratory rate, arterial blood pH, body temperature (T), mean arterial pressure (MAP), arterial oxygen pressure (PaO_2), and the serum concentrations of K^+, Na^+, creatinine and hematocrit were also measured in order to calculate the acute physiological score in APACHE II score.

Statistical analysis

Data were expressed as mean±SD and were analyzed by *SPSS* 13.0. Paired *t*-test was used to compare means of paired samples, *t*-test was used for comparison of means between 2 groups, *chi-square* test was used for comparison of non-parametrical samples. *Pearson* correlation and *Spearman* rank correlation were used for correlation analysis. $p<0.05$ was defined as statistically significant.

RESULTS

Subjects general information

A total of 33 mechanically ventilated patients with COPD underwent the first IC measurements and only 27 patients (15 males, 12 females) finished the 7-day nutritional support and underwent the second IC measurements (1 male and 2 females died during the study period and 3 males withdrew from the ventilator), so 60 (27×2 + 1 + 2 + 3) groups of REEm were obtained. Among 27 patients, 11 patients were given En-gen treatment and 16 were given En-low treatment.

Comparison of $REE_{H\text{-}B}$ and its corrected values with REEm

REEm of mechanically ventilated patients were compared to $REE_{H\text{-}B}$ and its corrected values by paired *t*-test (*n*=60). The results showed that REEm was significantly higher than $REE_{H\text{-}B}$ and $REE_{H\text{-}B}$×1.2 in all subjects, males, and females ($p<0.01$). There was no significant difference between REEm and $REE_{H\text{-}B}$×1.5 in males or all subjects. Only in females, REEm was significantly lower than $REE_{H\text{-}B}$×1.5 ($p<0.05$) (Table 2). If the coefficient changed from 1.5 to 1.4, then there was no significant difference between REEm and $REE_{H\text{-}B}$ in females (the mean of $REE_{H\text{-}B}$×1.4 was 1571±99 kcal/d, p=0.357).

In order to evaluate the accuracy of the three calculation methods, pairwise comparison by the *Wilcoxon* rank test

Table 3. Deviation of predicted REE from measured REE

Predicted formula	Gender	The relationship of REEm					
		Overestimate		Accuracy		Underestimate	
		sample numbers	%	sample numbers	%	sample numbers	%
H-B	Males	0	0.0	2	5.7	33	94.3
	Females	0	0.0	4	16.0	21	84.0
	Total	0	0.0	6	10.0	54	90.0
H-B×1.2	Males	0	0.0	9	25.7	26	74.3
	Females	3	12.0	11	44.0	11	44.0
	Total	3	5.0	20	33.3	37	61.7
H-B×1.5	Males	10	28.6	14	40.0	11	31.4
	Females 1.5	14	56.0	10	40.0	1	4.0
	Females 1.4	9	36.0	14	56.0	2	8.0
	Total	24	40.0	24	40.0	12	20.0

REE, resting energy expenditure; REEm, measured REE; H-B, Harris-Benedict equations.

Table 4. Comparison of accuracy between 1.2×H-B and 1.5×H-B (1.4 in females)

REE_{H-B}×1.2†	REE_{H-B}×1.5(1.4)		χ^2 value	*p* value
	Accuracy	Overestimate/Underestimate		
Accuracy	5	14	1.36	0.243
Overestimate/Underestimate	22	19		

† REE_{H-B}, predictive Resting Energy Expendure by Harris-Benedict equations.

was used to compare the underestimated percentages, accurate percentages, and overestimated percentages of REE_{H-B}, REE_{H-B}×1.2, and REE_{H-B}×1.5 (1.4 in female). It showed that the accuracy rates of the three methods were significantly different in males, females, or all subjects (all p=0.000) (See table 3). We combined “Overestimated” and “Underestimated” together as “Inaccurate” and compared it with “Accurate” by paired *chi-sqaure* test (*McNemar* test). It showed that there was no significant difference between REE_{H-B}×1.2 and REE_{H-B}×1.5 (1.4 in female) (p>0.05) (See table 4).

Correlation analysis between REEm and APACHE II score, M_{Lip}, and M_{CHO}

Spearman rank correlation analysis showed that there was significantly positive correlation between REEm and APACHE II score (p<0.05 or p<0.01) in males, females, or all subjects. *Pearson* correlation analysis showed that in males and all subjects, REEm had significantly positive correlation with M_{Lip} (p<0.05), but there was no any significant linear correlation between REEm and M_{CHO} (p>0.05) (See table 5) in males, females, or all subjects.

Effect of nutrition support in mechanically ventilated COPD patients

REEm before and after nutrition support were compared by paired *t*-test. It showed that there was no significant difference of REEm before and after treatment (p>0.05) (See table 6).

There was no significant difference between En-gen and En-low groups in Hb, TLC, Alb, Tf, and PA values, both before and after treatments (t-test, p>0.05). Paired *t*-test showed that Hb decreased significantly after nutrition support in En-gen group (p<0.05), while in En-low group there was no significant change in Hb (p>0.05). Both En-gen and En-low groups had significantly increased TLC after treatment. Transferrin and PA increased significantly after nutrition support in En-low group (p<0.05 and p<0.01), while Tf and PA in En-gen group, and Alb in both groups did not change significantly (p>0.05) after nutrition support (See table 7).

DISCUSSION

The application of IC and H-B for estimating energy requirements in mechanically ventilated patients with COPD

How to conveniently and accurately determine the energy requirement in mechanically ventilated patients with COPD is a major concern for clinical nutrition support. IC is rarely used to measure energy requirement in patients clinically. Instead, predictive equations or expert experience are often used to decide the energy requirement. Although they are convenient to use, predictive equations have some major defects. Some researchers suggest using certain multiplying factors (correction coefficient) to increase the accuracy of predictive equation HB in the absence of IC. For instance, the correction coefficient is 1.2 for bedridden patients,[23] 1.2-1.4 for patients with infection, and 1.5 for those with systemic inflammatory reaction.[18] Others recommend to use standard body weight to improve the accuracy of predictive REE.[24] Researches also find that not all mechanically ventilated patients are in hyper-metabolic state, and the degree of stress response is different in those hyper-metabolic patients.[25-27]

In this study, REEm was approximately 45.0% (49.1% in male, 36.8% in female) higher than REE_{H-B}, suggesting that mechanically ventilated patients with COPD were in hyper-metabolic state. Only 6 patients had REE_{H-B} that the accuracy of REE_{H-B} was within ±10% of REEm. REE_{H-B}×1.2 were still significantly lower than REEm in these patients. Only REE_{H-B}×1.5 in males and REE_{H-B}×1.4 in females were close to REEm. Thus REE_{H-B}×1.5 (using

Table 5. Correlation analysis between REEm and APACHE II score, M_{Lip}, and M_{CHO}

Correlation factor	REEm					
	Males (*n*=35)		Females (*n*=25)		Total (*n*=60)	
	r	*p* value	*r*	*p* value	*r*	*p* value
APACHE II†	0.449	0.002	0.259	0.031	0.324	0.011
M_{CHO}‡	0.096	0.584	0.327	0.111	0.206	0.114
M_{Lip}‡	0.352	0.038	0.049	0.816	0.259	0.049

†*Spearman* rank correlation analysis
‡*Pearson* correlation analysis

Table 6. Comparison of REEm before and after nutrition support (mean ± SD, kcal/d)

Date of nutrition support	REEm (kcal/d)		
	Males (*n*=15)	Females (*n*=12)	Total (*n*=27)
In that day	1854±306	1406±221	1675±332
After 7 days	1977±478	1551±402	1793±469
p value	0.218	0.345	0.111

standard body weight) in males, and $REE_{H\text{-}B}\times1.4$ (using standard body weight) in females are appropriate to be used to estimate energy requirement for mechanically ventilated patients with COPD.

However, the above methods still cannot accurately reflect REE of all patients because of individual difference in stress metabolism. The accuracy rates were 40% in males and 56% in females (Table 3), which indicating that another half were either overestimated or underestimated. For this reason, IC is widely used in clinic to measure REE and to direct clinical nutrition support in patients.[28,29] Besides, measured REE directly represent total energy requirement without any correction.[7] H-B equations are also an effective method of predicting REE[5, 30] if metabolic cart is not available to measure REE. Because of its inaccuracy, however, dietitians should observe patients' symptoms and biomarkers carefully during nutritional support, like the changes of triglycerides, blood glucose, liver and kidney functions during parenteral nutrition support, the change of blood glucose, development of abdominal distension, diarrhea, and sense of hunger in conscious patients during enteral nutrition support.[31]

The characteristics and influencing factors of energy metabolism in mechanically ventilated patients with COPD

The metabolism of energy, protein, carbohydrate, and fat changes in mechanically ventilated patients with COPD due to hyper-metabolism. Their heart rates, respiratory rates, and blood pressures change too. APACHE II score is often used to determine the severity and prognosis of disease in all ICU adult patients.[32, 33] In this study, we only selected the acute physiological part of the score system to investigate its relationship with REEm. It showed that REEm had significant linear correlation with acute physiological scores. This correlation suggests that both REEm and acute physiological scores are under the influence of stress response, they increase simultaneously when stress increases. When predicting REE with H-B equations in these patients, correction coefficient based on the acute physiological score may be used in order to estimate energy requirement more accurately. But additional studies are needed to determine the relationship between acute physiological score and correction coefficients for H-B equations.

Adrenalin secretion in the condition of trauma and mechanical ventilation can induce the increase of blood glucose. The metabolism and oxidation of glucose is twice of the normal level, and carbon dioxide release increases, too.[34] REE positively correlates with the energy from glucose oxidation, ie, the more glucose oxidizes, the higher

Table 7. Comparison of markers of nutritional status before and after nutrition support (mean±SD)

Nutrition marker	Date of nutrition support	En-gen group (*n*=11)	En-low group (*n*=16)	Total (*n*=27)	*p* value†
Hemoglobin (g/L)	In that day	116±25	115±30	115±28	0.894
	After 7 days	98±24	109±24	104±24	0.257
	p value‡	0.015	0.264	0.012	-
total lymphocyte count ($\times10^9$/L)	In that day	0.70±0.30	0.72±0.40	0.71±0.36	0.873
	After 7 days	1.11±0.36	0.94±0.27	0.97±0.31	0.520
	p value	0.003	0.005	0.000	-
Albumin (g/L)	In that day	31.3±6.1	33.1±6.7	32.4±6.4	0.464
	After 7 days	31.2±4.1	32.7±7.3	32.1±6.1	0.499
	p value	0.957	0.827	0.828	-
Transferrin (g/L)	In that day	1.50±0.61	1.51±0.47	1.50±0.52	0.989
	After 7 days	1.61±0.58	1.81±0.45	1.73±0.50	0.345
	p value	0.335	0.001	0.002	-
Prealbumin (mg/L)	In that day	119±54	123±24	122±38	0.832
	After 7 days	137±83	139±22	138±54	0.933
	p value	0.294	0.018	0.029	-

†represent *p* value compared between En-gen group and En-low group by *t*-test; ‡represent *p* value before and after nutrition support at same group by paired *t*-test.

the REE.[35] However, we did not observe significant correlation between REE and energy from carbohydrate. Stress response can induce the secretion of lipolytic hormones (such as adrenalin, noradrenalin, glucagon and so on). These hormones enhance the mobilization and decomposition of fat, which provides 75%-95% of body energy requirement.[36] In this study, REE in males had significantly positive correlation with energy from fat oxidation, which may suggest that REE in these male mechanically ventilated patients with COPD mainly came from fat oxidation. This correlation did not exist in female subjects. Maybe, the reason is that the percentage of body fat in females is higher than that in males.[37] But, future studies are needed to elucidate mechanisms of gender differences of the relationship between REE and fat oxidation.

The clinical effects of different energy support therapy

Malnutrition is common in COPD patients even before they receive mechanical ventilation due to the chronic process of the disease.[38-40] Nutrition support is thus especially important to COPD patients. Researches focus on how much energy and nutrients should be provided to be clinically effective. Cerra developed the concept of metabolic support in 1987, which is different from nutritional support. The idea is to provide appropriate amount of nutrients under severe catabolism condition. This can not only prevent the development of substrate-limited metabolism in organs, but also avoid the damage to organ structure and function caused by oversupply of nutrients.[41] For this purpose we must decide how much energy is enough to meet energy requirements in patients. Overfeeding may lead to hyperglycemia, hyperlipidemia, and azotemia, aggravate the burden of heart, lung, liver, and kidney, cause serious metabolic disorders, and increase carbon dioxide release in patients.[26,42,43] It also increases respiratory burden and delay weaning from ventilator, thus affects clinical therapy.

In our nutritional support treatment study, patients were divided into two groups, En-gen group who received 90%-130% of measured REE, and En-low group who received 50%-90% of measured REE.[22] After nutrition support, both groups had significantly increased TLC levels. Transferrin and PA increased significantly in En-low group but not in En-gen group. These results suggest that the improvement of protein nutritional status in En-low group was better than that of En-gen group. It is likely that the hypocaloric nutrition support may reduce the release of inflammatory mediators and catabolic hormones at the initial stage of stress response.[44] However, both treatments did not change blood plasma albumin and hemoglobin significantly. The possible reason is that the half life of these two proteins is relatively long and the speed of protein synthesis is also fairly low, so short-term nutrition support could not improve their values significantly. Another possible reason is blood loss caused by medical procedures such as blood collection. From the point of health-economical consideration, since hypocaloric metabolic support can improve protein nutritional status better than general calorie nutrition support, it is appropriate to provide 50%-90% of the measured REE to mechanically ventilated COPD patients to improve their nutritional status and ameliorate clinical benefits, especially in obese patients.[16]

Conclusion

We used metabolic cart to measure resting energy expenditure (REEm) in mechanically ventilated patients with COPD, and used Harris-Benedict equation to calculate resting energy expenditure ($REE_{H\text{-}B}$) with standard body weight. We compared $REE_{H\text{-}B}$ and its corrected values with REEm. We also evaluated the relationship between REEm and APACHE Ⅱ score, and between REEm and energy from carbohydrate and fat. In addition, we observed the effect of 7 days of nutrition support on metabolism of patients in the En-low group and the En-gen group. Conclusions are as follows:

1. These patients' resting energy expenditure increased.
2. Since IC is the best method to determine REE, in the absence of IC, H-B equation (with standard body weight) can be used to calculate REE, but the value should be adjusted by correction coefficients derived from APACHE II.
3. Low energy support during mechanical ventilation in COPD patients might have better effects on improving protein status than high energy support.

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AUTHOR DISCLOSURES

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled "Comparison between measured and predicted resting energy expenditure in mechanically ventilated patients with COPD".

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Original Article

Comparison between measured and predicted resting energy expenditure in mechanically ventilated patients with COPD

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用机械通气的慢性阻塞性肺病患者测定的与预测的静息能量消耗之比较及临床应用分析

为了研究机械通气的慢性阻塞性肺病(COPD)患者的能量代谢特点，比较间接测热法测定与Harris-Benedict公式预测的静息能量消耗(REE)的差异。并以此为依据，分析低能量的营养支持是否能改善患者蛋白质营养状况。纳入了33例(男20例，女13例)COPD患者，并测定其REE。比较测定的REE(REEm)和H-B公式计算的REE(REE_{H-B})及其校正值之间的差异，同时还分析了REEm与APACHEⅡ评分之间的关系。33例患者被随机分成低能量组(REEm的50%-90%)和常规能量组(REEm的90%-130%)，按照以上标准进行营养支持。比较营养支持前和支持后7天的白蛋白、前白蛋白、转铁蛋白、血红蛋白和淋巴细胞计数。REE_{H-B}和用1.2校正的值均明显低于REEm($p < 0.01$)；REEm与APACHEⅡ评分之间存在正相关($p<0.05$或$p<0.01$)。营养支持后，常规能量组的血红蛋白明显降低($p<0.05$)，两组患者的淋巴细胞计数，以及常规能量组的转铁蛋白和前白蛋白均明显升高($p<0.05$或$p<0.01$)。结果提示：1)机械通气的COPD患者的REE升高；2)间接测热法是确定REE的最好方法，在不能作间接测热法時，Harris-Benedict公式可用于计算患者的REE，但要参照APACHEⅡ评分予以校正；3)低能量的营养支持在改善机械通气COPD患者的蛋白质营养状况优于常规能量的营养支持。

关键字：静息能量消耗、间接测热法、机械通气、APACHEⅡ评分、能量消耗预测公式