Original article

Energy expenditure in acute pancreatitis evaluated by the Harris–Benedict equation compared with indirect calorimetry

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SUMMARY

Objectives: Enteral nutrition (EN) is recommended for severe acute pancreatitis (AP) and for biliary AP if cholecystectomy is delayed. Energy expenditure (EE) is calculated using the Harris–Benedict equation (HBE), but indirect calorimetry (IC) can also be employed. We wished to compare EE evaluated by the HBE equation, modified HBE (mHBE) and IC at study inclusion and 1 month after AP resolution.
Methods: We undertook a single-center prospective study in Paris, France.
Results: Among 35 patients, 19 had biliary AP and 11 alcoholic-related AP. Eleven cases had severe AP. There was no significant difference between EE calculated by the HBE and that using IC at study inclusion. However, the EE calculated by the mHBE was significantly higher than that calculated using IC. For severe AP, the HBE underestimated EE whereas the mHBE overestimated it. No difference was found based on the cause of AP. There was no difference between methods for EE at 30 days.
Conclusions: The HBE underestimated EE for severe AP, whereas the mHBE overestimated it. IC seems to be the best means of EE evaluation for AP.

1. Introduction

Nutritional therapy is an essential part of acute pancreatitis (AP) treatment. For severe AP, fluid perfusions and enteral nutrition (EN) can decrease the risk of organ failure and mortality [1]. Recent guidelines have underscored that EN should be primary therapy in patients with predicted severe AP [2]. EN can also decrease the risk of systemic infections [3,4]. For non-severe AP, EN reduces the intensity and duration of abdominal pain, and decreases the risk of food intolerance. One meta-analysis has shown the advantages of EN compared with a nil-by-mouth diet [1,5].

After biliary AP, there is a risk of relapse while patients wait for cholecystectomy or endoscopic sphincterotomy. Some scholars believe that patients should be placed under EN during this period [2]. Elemental or polymeric EN formulations can be used for AP treatment.

When nasogastric EN is started, energy expenditure (EE) is usually calculated using the Harris–Benedict equation (HBE), which is the most widely used method to determine EE in everyday practice. A modified version of the HBE (mHBE) is used to more accurately calculate EE taking into consideration physical exercise or stress. However, the mHBE does not take into account body composition, systemic inflammation, or drug effects [6].

EE can also be estimated by indirect calorimetry (IC) [7]. IC is used to measure the oxygen consumption and production of carbon dioxide that correspond to cellular respiration, and allows calculation of whole-body EE. IC is the most accurate method to measure EE, especially for intensive care unit (ICU) patients [8–10]. Several studies have shown the poor accuracy of such equations, especially the HBE, for hospitalized patients compared with IC [8,9]. Other studies have described EE underestimation using mathematical equations [11,12]. Only Dickerson and colleagues compared IC and the HBE among 13 AP patients [13]. They concluded that the HBE was an unreliable estimate of EE compared with that using IC.

The aims of our study were to compare: (i) EE evaluated by the HBE, mHBE and IC for patients with AP at inclusion and 1-month

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later in patients placed under EN; (b) the HBE, mHBE and EE estimated by IC depending on the severity and cause of AP.

2. Methods

2.1. Definitions

"AP" was defined on the basis of having two out of three of: upper abdominal pain; serum lipase more than three times the upper limit of normal; evidence of AP upon computed tomography (CT).

"Severe AP" was defined by systemic inflammatory response syndrome at the diagnosis with organ failure or a Computed Tomography Severity Index ≥4 [14,15]. "Mild" and "moderate" AP was defined using the Atlanta Consensus, and included as "non-severe AP" because of the low number of patients in each group [14].

2.2. Exclusion criteria

Exclusion criteria were patients who refused EN or IC and those aged <18 years.

2.3. Patients

Between May 2016 and July 2017, all consecutive patients hospitalized for AP with an indication of EN in the Department of Gastroenterology of Bichat Hospital (Paris, France) were included.

Upon study inclusion, demographic data were collected: age, sex, alcohol consumption and the body mass index (BMI). Between 48 h and 72 h after pain onset, the C-reactive protein (CRP) dose and serum levels of albumin were documented, and contrast-enhanced CT of the abdomen done.

A reference diet was used to calculate EE. The HBE (kcal/24 h) is:
HBE = 66.47 + 13.75 (weight) + 5.003 (height) − 6.755 (age) for males and HBE = 655.1 + 9.563 (weight) + 1.850 (height) − 4.676 (age) for females.

The mHBE was calculated at inclusion by multiplying the results by 1.2.

2.4. Procedures

IC was undertaken by a trained dietician using a calorimeter (Fitmate™; Cosmed, Rome, Italy) during the first 48 h after the diagnosis. Patients were at fasting and resting states with no physical stress. Oxygen consumption and production of carbon dioxide were measured by analyses of expired gases, and enabled calculation of the respiratory quotient and EE at rest. After device calibration, patients were studied for ≥20 min. The calorie intake for EN was prescribed using IC results.

EN was done until cholecystectomy for biliary AP or until evaluation at 1 month with a physical examination, dose of CRP and albumin levels, and CT. EN was stopped if the patient had no pain and CT showed improvement in the inflammation caused by AP. A second IC reading was undertaken during this evaluation.

2.5. Statistical analyses

Statistical analyses were carried out using SPSS v10.0 (IBM, Armonk, NY, USA). Continuous variables are presented as the mean ± standard deviation and were evaluated using descriptive analyses. Categorical variables are presented as percentages. The chi-square test or Fisher's exact test were used for comparisons between categorical variables. Independent-sample and paired-sample t-tests were used to ascertain differences between continuous variables. $p \leq 0.05$ was considered significant.

3. Results

Thirty-five patients (23 males, 12 females; median age, 51.5 (range, 28–90) years) formed the study cohort. The median BMI was 26 (17.4–31.3) kg/m². Only two patients had a BMI <18.5 and >30 kg/m², respectively. Causes of AP were: biliary lithiasis (n = 19), alcohol abuse (n = 11), tumor (n = 1) and unknown (n = 4) after complete work-up. Eleven patients (31%) had severe AP.

Upon study inclusion, the median albumin level was 34 g/L, and was 40 g/L at 1 month. The median > CRP upon study inclusion was 109 mg/L. The PCR was significantly higher between severe-AP and non-severe-AP patients (234 versus 78 mg/L, p < 0.05). The median EE (in Kcal) calculated using the HBE, mHBE and IC was 1585, 1900, and 1558, respectively (p < 0.001) (Table 1). The HBE underestimated EE compared with that using IC. However, EE was overestimated using the mHBE for severe AP and non-severe AP (Table 2). There was no significant difference in EE using the HBE, mHBE or IC between patients with AP due to alcoholism and those with biliary AP (Table 3).

Thirty days after study inclusion, 18 patients had a second evaluation, and there was no significant difference in EE irrespective of the method used for the estimation of EE and AP severity upon study inclusion. Seventeen patients stopped EN within 30 days because of intolerance. Four patients stopped EN within 30 days because of gallbladder surgery.

4. Discussion

Our prospective study showed that the mHBE overestimated EE in all AP patients. The HBE underestimated EE for patients with severe pancreatitis by 5%, whereas the mHBE overestimated it by 15%. This is the first study to demonstrate the use of IC for EN in AP.

AP carries with it a major risk of infection and complications as well as the requirement for ICU care. Assessment of EE constitutes the basis of efficacious nutrition planning.

EN can be employed using elemental or polymeric formulations. Once EN is started, the total calories are calculated using the HBE. The latter was created in 1919 and was used first for diets in healthy people. It is used widely for many physical states. However, studies have shown that it has limitations for certain populations, such as the obese and older individuals. Obese patients constitute an increasing proportion of hospitalized patients, and their energy requirements are addressed particularly poorly by mathematical equations [16].

IC is used to evaluate EE mainly among ICU patients. In 2018, Zusman and al. undertook 5847 IC measurements for 1565 ICU patients. Agreement with EE between IC and HBE was met for only one-third of patients [17]. Those results confirmed the data from a study by De Waele and colleagues in 2013 [18]. Boullata and co-workers found that no mathematical equation predicted EE in hospitalized patients accurately, even for obese cases. EE calculated using the HBE was less than that calculated using IC, whereas it overestimated the EE for obese patients [8].

Oshima and colleagues reported that IC is the most accurate method to determine EE [6]. However, IC is not always available, and it must be repeated as physical status changes. IC use is also

Table 1
Energy expenditure (EE) calculated using the Harris–Benedict equation (HBE), modified HBE (mHBE) and indirect calorimetry (IC).

	Inclusion (n = 35)	D30 (n = 18)
HB (Kcal)	1585.11 ± 269.9	1595 ± 262.2
Corrected HB (Kcal)	1900.4 ± 322.9*	NA
IC (Kcal)	1558.3 ± 363.3*	1402.9 ± 212.9

*P < 0.05.

Table 2
EE calculated using the HBE, mHBE and IC depending on AP severity.

	Severe AP (n = 11)	Non severe AP (n = 24)
HB (Kcal)	1682 ± 263*	1540 ± 266**
Corrected HB (Kcal)	2016 ± 315**	1847 ± 318**
IC (Kcal)	1756 ± 492*	1467 ± 249**

*P = 0.03.
**P < 0.001.

Table 3
EE calculated using the HBE, mHBE and IC depending on the cause.

	Alcohol	lithiasis
HB (Kcal)	1767 ± 169	1449 ± 249
Corrected HB (Kcal)	2116 ± 200	1738 ± 299
IC (Kcal)	1779 ± 345	1423 ± 242

P NS.

hampered by: day-to-day variability between individuals; ambient temperature; physical stress; intravenous energy intake; expense due to equipment requirement; its time-consuming nature.

Only Dickerson and colleagues compared IC and the HBE formula for patients with AP (n = 13) or chronic pancreatitis (n = 24) [13]. EE was significantly greater for patients with pancreatitis complicated by sepsis. EE for non-severe AP and chronic pancreatitis was not significantly different. Dickerson and colleagues concluded that the HBE was an unreliable estimate of EE compared with IC.

Higher EE is suspected with AP, but we did not find it for non-severe AP when the HBE and IC were compared. The mHBE overestimated EE for 35 patients. Overfeeding is associated with a poor outcome and a worse tolerance of EN [6]. For severe AP, EE was underestimated by the HBE in the present study. It is unclear if EE assessment leads to improved outcomes. In the present study, data collected at 1 month were limited because of early cholecystectomy and poor tolerance of EN.

5. Conclusions

There is no need to correct the HBE, even for patients with severe AP. IC seems to be the best evaluation of EE for AP, but more studies are needed to confirm our results.

Conflict of interest

None.

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Appendix A. Supplementary data

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