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SHORT COMMUNICATION

A short period of fasting before surgery conserves basal metabolism and suppresses catabolism according to indirect calorimetry performed under general anesthesia

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Abstract It is recommended that the period of fasting before elective surgery should be shortened to facilitate a rapid recovery by preventing catabolism. We examined the effects of a short period of fasting on metabolism by performing indirect calorimetry (IC) under general anesthesia. A prospective observational study involving 26 consecutive patients who underwent elective surgery and whose metabolism was evaluated using IC during anesthesia was conducted. The patients were divided into two groups, those who fasted for <8 h (group S) and those who fasted for >10 h (group L). Oxygen consumption, the volume of carbon dioxide emissions (VCO_2), the respiratory quotient (RQ), resting energy expenditure (REE), and basal energy expenditure (BEE) were compared. The REE, VCO_2, and RQ of group L (17.7 ± 2.3 kcal/kg/day, 118.5 ± 20.8 ml/min, and 0.71 ± 0.12, respectively) were significantly lower than those of group S (19.7 ± 2.3 kcal/kg/day, 143.6 ± 30.9 ml/min, and 0.81 ± 0.09, respectively) ($P < 0.05$). In group L, the relationship between REE and BEE was weaker ($r^2 = 0.501$) and the BEE−REE slope was less steep (REE = 0.419BEE + 509.477) than those seen in group S ($r^2 = 0.749$ and REE = 1.113BEE − 376.111, respectively). Our findings suggest that a short period of fasting (<8 h) before surgery is more strongly associated with the conservation of basal metabolism.

Keywords Indirect calorimetry · Fasting · Preoperative · Respiratory quotient (RQ) · Resting energy expenditure (REE)

Over the past decade, many anesthesiology guidelines and enhanced recovery after surgery protocols have recommended the use of a shorter period of fasting (between 6 and 8 h) before the induction of anesthesia for elective surgery [1–3]. It is considered that this facilitates early recovery by avoiding catabolism.

Indirect calorimetry (IC) is a metabolic monitoring method used to evaluate nutritional state. IC provides data regarding the volume of oxygen consumption (VO_2) and the volume of carbon dioxide emissions (VCO_2), and the rates of anabolism and catabolism can be assessed by calculating the respiratory quotient (RQ) from VO_2 and VCO_2 [4].

However, few reports have used IC to evaluate the metabolic parameters of patients who undergo surgery. The purpose of this study is to determine whether a short period of fasting before surgery is more effective at attenuating catabolism using data obtained by performing IC under general anesthesia.

This single-center, prospective observational cohort study was conducted at Nagoya City University Hospital from May 2012 to August 2012 and was approved by the research ethics committee at Nagoya City University.

Consecutive patients (American Society of Anesthesiologists physical status I–II) who underwent elective surgery were enrolled. In our hospital, the period of fasting before surgery varies because the patients are left to decide exactly when they will start fasting before an operation. Usually, on the day before the operation the hospital will provide patients with a normal diet containing about

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35–40 kcal/kg/day, and the preoperative breakfast includes tea or water and one slice of bread. The fasting period was defined as the time from the consumption of the last hospital meal to arrival at the operating room (OR). The patients were divided into two groups, those who fasted for <8 h (group S) and those who fasted for >10 h (group L). The exclusion criteria included being <20 years; being obese [body mass index (BMI) $\geq$30]; or having liver disease, chronic or acute kidney disease, chronic obstructive pulmonary disease, or diabetes. In addition, any patient whose IC data were unstable due to changes in their vital signs was excluded.

Preoperative data were collected from each patient's clinical records together with other information including demographic data and information about their preoperative condition and the time when they last ate. Data collected regarding each patient's preoperative condition included gender, age, BMI, basal energy expenditure (BEE), body temperature (BT), heart rate (HR), and blood pressure (BP). Data collected during anesthesia included HR, BP, the anesthetic drugs administered, and VO_2/VCO_2 which was used to calculate resting energy expenditure (REE) and RQ.

Upon arrival at the OR, standard monitoring of vital parameters and the bispectral index (BIS XP; Aspect Medical, DeMeern, The Netherlands) was initiated. BP and HR were evaluated with an automatic blood pressure machine every 150 s from the start of general anesthesia to the start of the operation. The patients were given 100 % oxygen through a face mask for 3 min. General anesthesia was induced through the intravenous administration of propofol via target-controlled infusion at a concentration of 3 or 4 µg/ml combined with 2–4 µg/kg fentanyl, 0.25–0.3 µg/kg/min remifentanil, and 0.9 mg/kg rocuronium, which were delivered via tracheal intubation. After the initiation of anesthesia, the patients were given 40 % oxygen, and their end-tidal carbon dioxide pressure was maintained between 30 and 40 mmHg by mechanical ventilation with volume control ventilation. Their tidal volume was maintained at 8–10 ml/kg, and their positive end-expiratory pressure was maintained at zero. The anesthetic agents were adjusted to produce a BIS value of 40–60. Extracellular fluids that did not contain glucose or amino acids were administered before surgery.

From April 2012, we have used IC (Aeromonitor AE-310s; Minato Medical Science, Osaka, Japan) to evaluate the metabolic state of patients in the intensive care unit or OR. Before the measurements were started, the patients were kept on ventilation for >15 min after tracheal intubation in the supine position. Subsequently, we placed an IC sensor between the anesthetic air filter and the breathing circuit of the anesthesia machine to measure VO_2 and VCO_2 for 15 min before the start of the operation.

RQ and REE were calculated using the following equations:

$$\mathrm{RQ} = \mathrm{VCO_2}/\mathrm{VO_2}$$

$$\mathrm{REE\ (kcal/day)} = (3.94 \times \mathrm{VO_2} + 1.11 \times \mathrm{VCO_2}) \times 1.44$$

In this study, BEE was calculated using the Harris−Benedict equation, which is often used in clinical practice:

$$\text{Males: BEE (kcal/day)} = 66.47 + 13.75\mathrm{W} + 5.0\mathrm{H} - 6.76\mathrm{A}$$

$$\text{Females: BEE (kcal/day)} = 655.1 + 9.56\mathrm{W} + 1.85\mathrm{H} - 4.68\mathrm{A}$$

where W = weight (kg), H = height (cm), and A = age (years)

The primary outcome measure was the difference in RQ between the two groups. The Statistical Package for the Social Sciences (SPSS version 19.0; SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Data are presented as mean (standard deviation) or median (interquartile range) values. Numerical data including RQ, EE, VO_2, and VCO_2 were compared between the groups using the t test or Mann–Whitney U-test. Categorical data were analyzed using Yates' chi-squared test. The correlation between REE and BEE was analyzed using Spearman's correlation coefficient. For all analyses, a P value of <0.05 was considered to be significant.

Twenty-six patients who underwent elective surgery were enrolled in this study. Four patients were excluded as their IC data were incomplete due to instability in their vital parameters during the IC measurements. The median duration of the fasting period was 6.5 (6.3–7.0) h in group L and 18.0 (13.5–19.8) h in group S. There were no significant intergroup differences in the patients' background characteristics or vital parameters, including mean arterial pressure (MAP), HR, and BT, during the IC measurements (Table 1).

The RQ and VCO_2 of group L were significantly lower than those of group S ($P = 0.016$ and $P = 0.023$, respectively, Table 1), but VO_2 did not differ significantly between the groups ($P = 0.544$).

The mean REE value for all patients was 18.7 $\pm$ 2.4 kcal/kg/day; however, the REE of group L was significantly lower than that of group S (17.7 $\pm$ 2.3 vs 19.7 $\pm$ 2.3 kcal/kg/day, $P = 0.036$, Table 1).

The correlations between REE and BEE are shown in Fig. 1. The relationship between REE and BEE was weaker in group L ($r = 0.708$, $r^2 = 0.501$) than in group S ($r = 0.865$, $r^2 = 0.749$), and the BEE−REE slope of group L (REE = 0.419BEE + 509.477) was less steep than that of group S (REE = 1.113BEE − 376.111).

In this study, we investigated the effect of the duration of the preoperative fasting period on metabolism during anesthesia. Using IC data obtained under general anesthesia, we demonstrated that the VCO_2, RQ, and REE of the

Table 1 Characteristics of the study population and their indirect calorimetry data

	Group S ($n = 13$)	Group L ($n = 13$)	P value
Age (years)	43.0 (15.1)	53.0 (14.1)	0.094
Body mass index (kg/m^2)	22.9 (3.2)	23.3 (3.5)	0.765
Sex (male/female)	8/5	7/6	1.000
ASA status (1/2)	9/4	7/6	0.687
Duration of fasting period (h)	6.5 (6.3–7.0)	18.0 (13.5–19.8)	<0.001
HR (beats/min)	62.9 (5.0)	67.8 (8.4)	0.083
MAP (mmHg)	63.4 (12.4)	60.8 (7.9)	0.538
BT (°C)	36.3 (0.3)	36.2 (0.4)	0.646
BEE (kcal/day)	1,398.5 (201.2)	1,380.0 (268.1)	0.847
BEE (kcal/kg/day)	23.5 (2.3)	22.2 (1.9)	0.121
REE (kcal/day)	1,180.6 (258.9)	1,088.2 (158.8)	0.284
REE (kcal/kg/day)	19.7 (2.3)	17.7 (2.3)	0.036
RQ	0.81 (0.09)	0.71 (0.12)	0.016
VO_2 (ml/min)	177.3 (39.1)	169.3 (25.7)	0.544
VCO_2 (ml/min)	143.6 (30.9)	118.5 (20.8)	0.023

Data are shown as mean (standard deviation), median (interquartile range), or absolute values

Significant difference between the two groups at $P < 0.005$

ASA American Society of Anesthesiologists, *HR* heart rate, *MAP* mean arterial pressure, *BT* body temperature, *BEE* basal energy expenditure, *REE* resting energy expenditure, *RQ* respiratory quotient, *VO_2* volume of oxygen consumption, *VCO_2* volume of carbon dioxide emissions

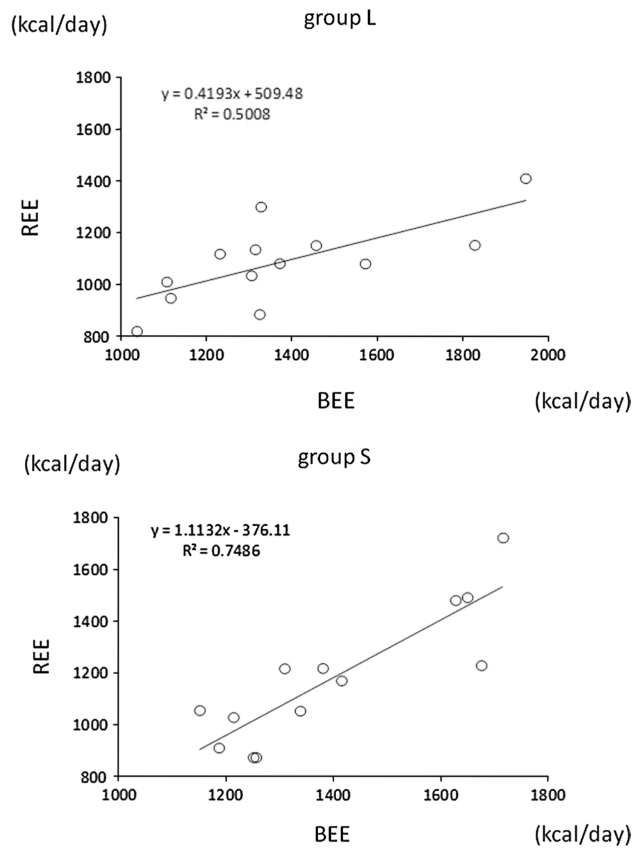

Fig. 1 The relationship between REE and BEE was strong in group S ($r = 0.865$) and moderately strong in group L ($r = 0.708$). REE was measured by IC. BEE was calculated using the Harris–Benedict equation

long-fasting period group were significantly lower than the short-fasting period group.

Some previous studies have reported REE data for critical patients under sedation. Terao et al. showed that the mean REE and REE/BEE values of such patients were approximately 865 kcal/day/m^2 and 1.13, respectively, even among patients under heavy sedation [5], and Miles reported a mean REE/BEE value of 1.13 [6]. These values are higher than those obtained in the present study (group S, 738 kcal/day/m^2 and 0.84, respectively; group L, 680 kcal/day/m^2 and 0.79, respectively). One possible explanation for these differences is that the patients involved in the above-mentioned studies received conventional intensive care therapy, and invasive therapy enhances energy expenditure (EE), as it results in stimulation of the sympathetic nervous system due to the release of stress hormones and cytokines. On the other hand, as the patients who took part in our study were placed under general anesthesia before surgery, their EE would have been markedly reduced.

Generally, if a patient becomes excessively hungry, gluconeogenesis will start to occur in the liver, i.e., the production of glucose from glycogen. After fasting for approximately 20 h, the catabolism of fat and protein to produce energy starts before an individual's glycogen stores are completely depleted. Fat catabolism occurs sooner than protein catabolism. In addition, CO_2 production is decreased by fat burning, which results in reductions in VCO_2 and RQ. Although the REE of group S was higher and the relationship between REE and BEE was stronger than those seen in group L, some studies have shown that the relationship between fasting and EE changed after only about 2 days of starvation [7, 8]. In the present study, the REE of group S might have been elevated by an increase in specific dynamic action, i.e., the amount of energy used to break down and process food.

Our study has several limitations. First, the amounts of food and drink consumed and the types of surgery performed were not standardized among the patients so the amount of energy substrates available to each patient and/or the invasiveness of the operations might have differed. Second, only VO_2 and VCO_2 were used to evaluate metabolism, and no blood or urine tests were performed. To confirm the results obtained with IC in this study, markers of fat or protein catabolism should be assessed. Third, the fasting time of group S should have been approximately 8 h to exclude the possibility of SDA.

In conclusion, our findings suggest that a short period of fasting before surgery is more strongly associated with the attenuation of catabolism by performing IC.

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