Comparisons of Predictive Equations for Resting Energy Expenditure in Patients with Cerebral Infarct during Acute Care

Ayano Nagano, RN,* Yoshitaka Yamada, MD, PhD,† Hiroji Miyake, MD, PhD,† Kazuhisa Domen, MD, PhD,‡ and Tetsuo Koyama, MD, PhD‡§

Background: Estimation of resting energy expenditure (REE) is essential in planning nutrition support. Several equations are used for this estimation in the clinical setting. The purpose of this study was to compare the predictive accuracy of existing equations for REE in patients with cerebral infarct during acute care. *Methods:* We assessed the Harris–Benedict, Mifflin, Owen, Japanese simplified, Wang, and Cunningham equations. The Owen and Japanese simplified equations use sex and weight as explanatory variables, the Harris–Benedict and Mifflin equations include sex, weight, age, and height, and the Wang and Cunningham equations use fat-free mass (FFM) measured using bioelectrical impedance technology. Actual REE values were measured by indirect calorimetry on days 2 and 7 and were then averaged. Applying analysis of variance, predictive accuracy was assessed by comparing the predicted and actual values. *Results:* A total of 30 patients were analyzed. Actual REE values ranged from 796 to 1637 kcal (mean, 1109). The standard deviation of these values was the smallest with the Harris–Benedict equation (99), followed by the Cunningham (165), and Wang (181) equations. The Mifflin equation underestimated REE in females, whereas the Owen and Japanese simplified equations tended to overestimate it. *Conclusions:* Based on our results, the Harris–Benedict equation provides the most accurate prediction of REE. In addition, the Cunningham and Wang equations may be useful in long-term care settings involving patients at risk of malnutrition resulting in uneven loss of FFM relative to weight. **Key Words:** Diet—formula—metabolism—prediction—stroke.

Starting nutrition support therapy is critically important for improving both mortality and outcomes for patients after stroke.[1-4] To provide optimal nutrition care, it is essential to accurately estimate resting energy expenditure (REE).[5] Several techniques have been developed for this purpose.

Although direct calorimetry is considered the most accurate method for measuring REE,[6] it requires a special apparatus that encapsulates the entire body, which places a burden on both patients and medical staff. Consequently, it is rarely applied in daily clinical practice. In contrast, indirect calorimetry, a technique based on sampling and analysis of expiratory gas collected by a face mask, is more practical.[7-9] Although this system is generally much easier to use compared with that in direct calorimetry, it still requires strict control in regard

From the *Department of Nursing Care, Nishinomiya Kyoritsu Neurosurgical Hospital, Nishinomiya, Hyogo; †Department of Neurosurgery, Nishinomiya Kyoritsu Neurosurgical Hospital, Nishinomiya, Hyogo; ‡Department of Rehabilitation Medicine, Hyogo College of Medicine, Nishinomiya, Hyogo; and §Department of Rehabilitation Medicine, Nishinomiya Kyoritsu Neurosurgical Hospital, Nishinomiya, Hyogo, Japan.

Received March 28, 2015; revision received April 16, 2015; accepted April 21, 2015.

This study was supported in part by a Grand-in-Aid for Scientific Research (B), the Japan Society for the Promotion of Science (KAKENHI [25282168]), and the Medical Research Fund of Hyogo Medical Association (MRF-H-10-14).

The authors declare that they have no conflicts of interest.

Address correspondence to Tetsuo Koyama, MD, PhD, Department of Rehabilitation Medicine, Nishinomiya Kyoritsu Neurosurgical Hospital, 11-1 Imazu-Yamanaka-cho, Nishinomiya, Hyogo 663-8211, Japan. E-mail: koyama.t@nk-hospital.or.jp.

1052-3057/$ - see front matter

http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2015.04.029

to meal consumption, rest duration, and posture before sampling. Owing to these limitations, estimating REE in daily clinical practice is most frequently carried out using predictive equations.[10] Various predictive equations have been proposed,[11-16] several of which are widely used in clinical practice.[11,12,14] However, only a small number of studies have systematically assessed the accuracy and clinical utility of these equations in patients after stroke during acute care.

The aim of this study was to assess the accuracy and utility of existing predictive equations for acute stroke care. Among all types of stroke, cerebral infarct is the most common (approximately 65%) in Japan.[17] In this study, to minimize variability arising from stroke type, we focused only on patients with cerebral infarct. In combination with indirect calorimetry, we compared the predictive accuracy and clinical utility of 6 existing predictive equations for REE.

Methods

Patients

This study included patients who were diagnosed as having cerebral infarct and admitted to the stroke care unit (SCU) at Nishinomiya Kyoritsu Neurosurgical Hospital from April 2014 to February 2015. Most of these patients were transferred to our hospital soon after onset. Diffusion-weighted magnetic resonance imaging was used to diagnose cerebral infarct in all patients.[18] Scores on the National Institute of Health Stroke Scale (NIHSS)[19] and the modified Rankin Scale (mRS)[20] were recorded on admission. Inclusion criteria for analysis were patients who lived independently in their community before admission to the hospital, whose severity of stroke symptoms on admission according to NIHSS score was between 4 and 25,[21] and who stayed in our SCU for at least 1 week. Patients who subsequently required acute medical services, including oxygen therapy, assisted ventilation, acute infection necessitating antibiotic treatment, or congestive heart failure, were excluded from analysis. Patients who had evident metabolic disorders, including advanced cancer with or without chemotherapy or poorly controlled diabetes mellitus, were also excluded. Written informed consent for inclusion in the study was obtained from all patients or their family members, and the study protocol was approved by the Institutional Review Board of Hyogo College of Medicine.

REE Measurement by Indirect Calorimetry

Indirect calorimetry was used to measure REE. FitMate (Cosmed, Rome, Italy),[22] a portable metabolic analyzer designed to measure oxygen consumption and energy expenditure, was used to obtain measurements. FitMate uses standard metabolic formulas to calculate oxygen consumption; a fixed respiratory quotient (RQ) of .85 is used to calculate energy expenditure.[22] The gas analyzer was automatically calibrated before each test. Measurements were taken between 6 AM and 8 AM at least 9 hours after the last meal and after the patient had been in a recumbent position for at least 30 minutes. Patients were asked to keep supine position and breathe normally for 15 minutes during the measurements. Calculated energy expenditure was continuously monitored every minute. Heart rate, respiratory rate, and blood pressure were also monitored. Data obtained during the first 5 minutes were discarded because of stabilization reasons. Patients who could not keep still or who had poorly fitting masks were excluded from the final analysis. Data were collected on days 2 and 7 and then averaged and were used as actual REE values in the statistical analysis.[22] The test–retest reliability and clinical utility of FitMate indirect calorimetry have been well established in previous literature.[22-25]

Predictive Equations for REE

In this study, we focused on the following 6 predictive equations for REE: Harris–Benedict,[12] Mifflin,[14] Owen,[13] Japanese simplified,[11] Wang,[16] and Cunningham.[15] The predictive accuracy of these existing equations for healthy subjects has been well established in previous literature.[11-16] Mathematical formulas for these equations are described in the Appendix.

Among these, the Harris–Benedict and Mifflin equations use sex, weight, age, and height as explanatory variables. The Owen and Japanese simplified equations use sex and weight as explanatory variables. The data for these explanatory variables were collected on admission.

The Wang and Cunningham equations employ fat-free mass (FFM) measured by a body composition analyzer (InBody S10; Biospace Co. Ltd, Seoul, Korea).[26-29] This apparatus measures the bioelectrical impedance of the subjects' right arm, left arm, trunk, right leg, and left leg at 6 different frequencies (1, 5, 50, 250, 500, and 1000 kHz) for each body part. Then, the weight of FFM and the ratio of extracellular water to total body water (ECW/TBW) were calculated. Measurements were taken soon after indirect calorimetry on day 2. Patients with implanted cardiac pacemakers were excluded for safety reasons.

Statistical Analysis

To assess the predictive accuracy of each equation, we applied a variation of analysis of variance. The mathematical procedure is as follows:

$$Variance = \frac{1}{N}\sum_{i=1}^{N}\left(Predicted\ REE_i - Actual\ REE_i\right)^2$$

where "i" is the sequential number assigned for each patient and "N" is the total number of samples (Table 1).