European Journal of Clinical Nutrition www.nature.com/ejcn

ARTICLE

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Do we need different predictive equations for the acute and late phases of critical illness? A prospective observational study with repeated indirect calorimetry measurements

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BACKGROUND: Predictive equations (PEs) for estimating resting energy expenditure (REE) that have been developed from acute phase data may not be applicable in the late phase and vice versa. This study aimed to assess whether separate PEs are needed for acute and late phases of critical illness and to develop and validate PE(s) based on the results of this assessment.
METHODS: Using indirect calorimetry, REE was measured at acute (≤5 days; $n = 294$) and late (≥6 days; $n = 180$) phases of intensive care unit admission. PEs were developed by multiple linear regression. A multi-fold cross-validation approach was used to validate the PEs. The best PEs were selected based on the highest coefficient of determination (R^2), the lowest root mean square error (RMSE) and the lowest standard error of estimate (SEE). Two PEs developed from paired 168-patient data were compared with measured REE using mean absolute percentage difference.
RESULTS: Mean absolute percentage difference between predicted and measured REE was <20%, which is not clinically significant. Thus, a single PE was developed and validated from data of the larger sample size measured in the acute phase. The best PE for REE (kcal/day) was 891.6(Height) + 9.0(Weight) + 39.7(Minute Ventilation)−5.6(Age) – 354, with $R^2 = 0.442$, RMSE = 348.3, SEE = 325.6 and mean absolute percentage difference with measured REE was: 15.1 ± 14.2% [acute], 15.0 ± 13.1% [late].
CONCLUSIONS: Separate PEs for acute and late phases may not be necessary. Thus, we have developed and validated a PE from acute phase data and demonstrated that it can provide optimal estimates of REE for patients in both acute and late phases.
TRIAL REGISTRATION: ClinicalTrials.gov NCT03319329.

European Journal of Clinical Nutrition; https://doi.org/10.1038/s41430-021-00999-y

BACKGROUND

Indirect calorimetry (IC) is the reference standard for measuring the energy expenditure of critically ill patients in the intensive care unit (ICU) [1, 2]. Optimizing energy provision with daily IC measurements in the ICU may confer clinical benefits [3–5]. However, IC is not commonly used [6]. This is due to the high cost, poor insurance reimbursement, and lack of trained personnel to operate the equipment and to interpret the results [7, 8]. Hence, clinicians need to rely on predictive equation (PE) for estimating patients' energy expenditure.

In the ICU, resting energy expenditure (REE) is calculated using PEs with variables such as weight, height, age, sex, body temperature and minute ventilation [9]. PEs developed in healthy populations, such as the Harris-Benedict [10] and Mifflin-St. Jeor equations [11], are widely used in the ICU setting. While PEs developed in the critically ill population, such as the Penn State [9], Swinamer [12], and Faisy [13] equations, were developed from Caucasians and data of patients in the acute phase (≤5 days). Our recent study found that none of the commonly used PEs could optimally estimate measured REEs of patients in different phases of critical illness [14]. Furthermore, we found that REE during the acute phase of critical illness is generally lower than the late phase (6–10 days), while REE in the chronic phase (≥11 days) was not significantly different from the late phase [14]. Based on these results, we hypothesized that the use of separate PE for the acute (≤5 days) and later phases (≥6 days; collectively known as the late

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Edited by Professor Claudio Maffeis

Received: 17 February 2021 Revised: 31 July 2021 Accepted: 11 August 2021