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Chapter 4

Guidelines for specialized nutritional and metabolic support in the critically-ill patient. Update. Consensus SEMICYUC-SENPE: Macronutrient and micronutrient requirements

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Abstract

Energy requirements are altered in critically-ill patients and are influenced by the clinical situation, treatment, and phase of the process. Therefore, the most appropriate method to calculate calorie intake is indirect calorimetry. In the absence of this technique, fixed calorie intake (between 25 and 35 kcal/kg/day) or predictive equations such as the Penn State formula can be used to obtain a more accurate evaluation of metabolic rate.

Carbohydrate administration should be limited to a maximum of 4 g/kg/day and a minimum of 2 g/kg/day. Plasma glycemia should be controlled to avoid hyperglycemia. Fat intake should be between 1 and 1.5 g/kg/day. The recommended protein intake is 1-1.5 g/kg/day but can vary according to the patient's clinical status.

Particular attention should be paid to micronutrient intake. Consensus is lacking on micronutrient requirements. Some vitamins (A, B, C, E) are highly important in critically-ill patients, especially those undergoing continuous renal replacement techniques, patients with severe burns and alcoholics, although the specific requirements in each of these types of patient have not yet been established. Energy and protein intake in critically-ill patients is complex, since both clinical factors and the stage of the process must be taken into account. The first step is to calculate each patient's energy requirements and then proceed to distribute calorie intake among its three components: proteins, carbohydrates and fat. Micronutrient requirements must also be considered.

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Key words: *Macronutrients. Micronutrients. Enteral nutrition. Parenteral nutrition.*

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SEMICYUC: Spanish Society of Intensive Care Medicine and Coronary Units.
SENPE: Spanish Society of Parenteral and Enteral Nutrition.

RECOMENDACIONES PARA EL SOPORTE NUTRICIONAL Y METABÓLICO ESPECIALIZADO DEL PACIENTE CRÍTICO. ACTUALIZACIÓN. CONSENSO SEMICYUC-SENPE: REQUERIMIENTOS DE MACRONUTRIENTES Y MICRONUTRIENTES

Resumen

Los pacientes críticos presentan modificaciones importantes en sus requerimientos energéticos, en las que intervienen la situación clínica, el tratamiento aplicado y el momento evolutivo. Por ello, el método más adecuado para el cálculo del aporte calórico es la calorimetría indirecta. En su ausencia puede recurrirse al aporte de una cantidad calórica fija (comprendida entre 25-35 kcal/kg/día) o al empleo de ecuaciones predictivas, entre las cuales la fórmula de penn State proporciona una evaluación más precisa de la tasa metabólica.

La administración de carbohidratos debe tener un límite máximo de 4 g/kg/día y mínimo de 2 g/kg/día. Deben controlarse los valores de glucemia plasmática con el fin de evitar la hiperglucemia. Respecto al aporte de grasa, debe estar entre 1-1,5 g/kg/día. El aporte proteico recomendado se encuentra entre 1-1,5 g/kg/día, aunque puede variar en función de las características de la propia situación clínica.

Debe prestarse una atención especial al aporte de micronutrientes. No hay un acuerdo unánime sobre los requerimientos de éstos. Algunas de las vitaminas (A, B, C, E) son de gran importancia para los pacientes en situación crítica, con especial atención en pacientes sometidos a técnicas continuas de reemplazo renal, grandes quemados y alcohólicos, aunque los requerimientos específicos para cada uno de ellos no han sido establecidos. El aporte de los requerimientos energéticos y proteicos a los pacientes críticos es complejo, dado que debe tener en cuenta tanto las circunstancias clínicas como su momento evolutivo. La primera fase del proceso es la del cálculo de las necesidades energéticas de cada paciente para, en una fase posterior, proceder a la distribución del aporte calórico entre los 3 componentes de éste: proteínas, hidratos de carbono y grasas, así como considerar la necesidad de aportar micronutrientes.

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Palabras clave: *Macronutrientes. Micronutrientes. Nutrición enteral. Nutrición parenteral.*

What methods can we used to estimate requirements and energy supply?

Indirect calorimetry and Fick method

Indirect calorimetry is the method clinically considered as gold standard. It shows several problems for its application, such as expensive equipment, need for time to perform measurements, staff with experience and lack of availability in most units. In addition, it tries to predict total energy expenditure (TEE) based on measurements performed within a short time interval (5-30 min), evidencing changes up to 20% during the day. Thus, to resting energy expenditure (REE) we should add 15-20% to calculate TEE, though it is most accurate to maintain the measurements for24 h to establish TEE[1] (III). The Fick method has not shown a good correlation with calorimetry and is rarely used in daily practice[2,3] (III).

Estimation methods

The literature includes over 200 formulae to estimate the energy expenditure (EE), none of which have shown a good correlation to measurements taken by indirect calorimetry. However, its use is recommended when calorimetry cannot be performed. For selecting the most appropriate formula, the type of patients evaluated to define them must be considered[4,5] (IIb). A study has been recently published, that includes 202 critical patients undergoing mechanical ventilation comparing indirect calorimetry using different formulas to calculate baseline EE. The authors concluded that the Penn State formula provides a more precise evaluation of the metabolic rate in critically-ill patients on mechanical ventilation[6] (Ib).

Correlation between measured and calculated energy expenditure

All the methods have shown a poor correlation with the EE measured, with overestimation in 80% of the cases, so it is considered that critically-ill patients are often a different population than that used as the basis for these formulae. The correlation is not good because the multiple variables of critically-ill patients[7] are not considered (III). A recent study shows that there is no good correlation between the intake of a fixed amount of calories (25 kcal/kg/day) and indirect calorimetry[8] (IIa), obtaining better results with the latter.

Energy supply

The needs will change based on the metabolic phase where the patient is: initial catabolic phase or recovery anabolic phase. If EE cannot be measured, a supply as close as possible to the requirements measured by indirect calorimetry in the initial phase is recommended to increase in more advanced convalescence phases, based on studies that show a higher incidence of infections as compared to negative calorie balance[9,10] (III) and better results with a positive calorie balance[11] (Ib). Some authors recommend supplementing with parenteral nutrition (PN) when the requirements are not met (60-70% of enteral supply). A meta-analysis of studies comparing enteral nutrition (EN) with mixed nutrition, applied from the patient admission, shows no lower incidence of infectious complications, days of stay at ICUs, or days on mechanical ventilation[12] (Ia).

The weight to be used in the formula will depend on body mass index (BMI) (see chapter 12). In patients with BMI < 18 kg/m^2 it is recommended to use the current weight, to prevent renutrition syndrome, and for all other patients the weight prior to the aggression, as the current weight shows major changes as a result of the initial resuscitation.

In recent years permissive hypoalimentation during the first phases of the critically-ill patient (18 kcal/kg body weight/day) is becoming increasingly accepted[13] (III), expecting to achieve the full objective of the requirements (25 kcal/kg/day) after the first week. Recent studies support this approach finding better clinical outcomes when calorie intake, during the first days of the catabolism phase, is between 33 and 66% of the estimated requirements[14] (IIb). Lower supplies would be associated with an increased number of bacteremias[15] (III) and higher with a higher complication rate[16] (IV). However, this recommendation cannot be established without a prospective study, which is not available yet.

What type of carbohydrates and what amount should be supplied in critically-ill patients?

Glucose is still the main calorie substrate in critically-ill patients. A glucose infusion at 4 mg/kg/min only suppresses neoglucogenesis in 50% and protein catabolism in 10-15%, so it is recommended never to administer a glucose supply greater than 4 g/kg/day. In general, carbohydrates represent 50% of the global energy requirements, though this percentage may vary depending on individual factors and the severity of aggression. Because of the supply and the metabolic stress, hyperglycemia occurs and has been associated with poorer clinical outcomes[17] (III). Multiple studies and meta-analyses were performed[18,19] (Ia), some of which recommend maintaining blood sugar at values between 140 and 180 mg/dL, using insulin if this limit is exceeded , though there is no consensus about the most appropriate limit value (see chapter 10). Higher values would be related to worse clinical outcomes, particularly in infectious complications, and attempting to maintain lower values would be associated with a higher incidence of severe hypoglycemia, without achieving benefitial effects on mortality.

In PN they are administered as dextrose and in EN as more complex sugars, disaccharides, maltodextrins, and starches, usually using those with a lower glycemic index.

What type of lipids and what amount should be provided in critically-ill patients?

Lipid intake must be a fundamental part of nutritional support since, in addition to providing energy in a small volume, it is essential to prevent essential fatty acids deficiency (at least 2% of calories as linoleic acid and at least 0.5% as linolenic acid) and to maintain the structure of cell membranes, and also to modulate intracellular signals[20,21] (IIb). Compared to carbohydrates, lipid supply causes a lower effect on thermogenesis, lipogenesis, stimulation of insulin release, CO_2 production and glycemia values. It is generally considered that ω-3 fatty acids may counteract the proinflammatory effects of ω-6[22] (III).

Fat supplying is safe and well tolerated at an amount of 0.7 to 1.5 g/kg/day[23] (IIa). It should be administered at concentrations of 30 or 20% vs 10%, resulting from a decreased supply of phospholipids (phospholipids/triglycerides ratio of 0.04 at the 30% concentration) and longer perfusions rather than in short periods to prevent changes in pulmonary ventilation/perfusion. There are various commercial formulations in the form of long-chain triglycerides (LCT), but currently the mixtures with middle-chain triglycerides (MCT), fish oil, or olive oil have been shown to be well tolerated and are used with preference over LCT. However, it is difficult to make a specific choice on the type to be used as non of them has shown significant advantages over the other[24,25] (IIb). They must not be administered, or their supply should be reduced, when plasma triglyceride levels are greater than 400 mg/dL[26]. Up to 40% of non-protein calories may be provided. With regard to EN, diets with a high ω-3 content from fish oil should be particularly indicated for patients with acute lung injury (ALI) and acute respiratory distress syndrome (ARDS)[27] (Ib), [28] (III) (see chapter 8).

What protein requirements and what type must be provided in critically-ill patients?

Although nitrogen losses can be very high, particularly in patients with injuries and burns, very high supplies are not recommended, as while protein supply at an amount of 1.5 g/kg/day decreases protein catabolism by 70%, its increase to 2.2 g/kg/day causes an increase in net protein degradation[29].

In PN, the normal supply is provided by formulations of standard amino acids, where the composition in essential amino acids is similar to the requirements of healthy individuals. The enrichment of PN with branched chain amino acids has been tested, particularly in septic patients[30] (IIa), but there is not sufficient evidence to justify their use (see chapter 15).

Currently there is sufficient evidence for the routine use of glutamine in critically-ill patients[31] (IV), [32] (Ib), [33] (Ib), where it acts as a conditionally essential amino acid. In PN 0.3-0.5 g/kg/day as glutamine-alanine dipeptides are recommended, which are more stable and soluble. Supply in EN has also shown a morbidity and even a mortality reduction in burn and in trauma patients[34] (Ia), though it has not been demonstrated in heterogeneous groups of critically-ill patients yet. Improved control of glycemia metabolism has been confirmed in patients receiving parenteral glutamine, as it would help to reduce insulin resistance[35,36] (IIa).

Intact proteins are generally used in EN. Oligopeptides have shown no clinical benefits in terms of outcomes or gastrointestinal complications. With regard to arginine supply, combined with other substrates by EN, its use is questioned in some specific populations of critical patients (see chapter 15), but some studies found benefits using immunonutrition diets providing arginine[37] (Ib).

What vitamins and trace elements are considered necessary or essential in critically-ill patients?

A combination of antioxidant vitamins and trace elements, including selenium, zinc and copper, can improve outcomes in critically-ill patients[38,39]. A meta-analysis of 15 randomized studies evidences that a combination of antioxidant vitamins and trace elements reduces mortality and the duration of mechanical ventilation, though it does not improve infectious complications or length of stay[40] (Ia).

Vitamin requirements are not established in artificial nutrition for critically-ill patients, though the recommendations of the *Nutrition Advisory Group* of the American Medical Association (AMA-NAG) are followed. Other authors follow the RDA recommendations, even though it is very likely that these are far below the needs of the patients under aggression. Supplying thiamine, niacin, and vitamins A, E and C, as well as other vitamins from complex B is considered to be essential.

Recommendations

– The most reliable method in daily practice to calculate energy expenditure is indirect calorimetry (A). The Fick method and estimation methods do not show a good correlation with energy expenditure measured by indirect calorimetry in critically-ill patients (B).

– In the absence of indirect calorimetry, it is recommended to provide an amount of 25 kcal/kg of current weight/day in patients with a BMI < 30 (C). In patients on mechanical ventilation the estimated calculation of calorie requirements is recommended according to the Penn State equation (B).

– With regard to intravenous administration of glucose, it is not recommended to exceed a supply of 4 g/kg/day (B).

– It is recommended, as most appropriate, to maintain glycemia levels below 150 mg/dl (C).

– The recommended lipid supply in parenteral nutrition is 0.7-1.5 g/kg/day (B).

– Any type of lipid emulsion existing in the current market may be used (B), but it is recommended to avoid single ω-6 supplies in critically-ill patients (C).

– In critically-ill patients, no specific formulation of amino acids has been defined for generic use (C). In general, the supply must be adjusted to an amount of 1-1.8 g/kg/day (B).

– In critically-ill patients intravenous administration of glutamine dipeptides (Ala-Gln) of 0.5 g/kg/day is recommended, complementing parenteral nutrition (A).

– The need for supplying micronutrients (vitamins and trace elements) is set (A), but the amount cannot be established.

Conflict of interests

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