Dietary Protein and the Critical Care Patient

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Proteins are macromolecules composed of dispensable and indispensable amino acids. The quality of a protein is a function of its digestibility and indispensable amino acid content. Critical care patients have an increased need for protein to meet their daily nitrogen and amino acid requirements. Delivering high quality protein to this population is crucial for their recovery.

What is protein?

Proteins are large molecules made up of amino acids linked together by peptide bonds. There are 20 amino acids.[1] Amino acids can be divided into two groups: indispensable (essential) and dispensable (non-essential). Indispensable amino acids cannot be synthesized by the body and must be obtained through the diet. There are nine indispensable amino acids, which include: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Dietary requirements for indispensable amino acids are presented in Table 1. The remaining amino acids (alanine, aspartic acid, asparagine, glutamic acid, serine, arginine, glutamine, glycine, proline, cysteine and tyrosine) are considered dispensable because they can be synthesized by the body. However, under specific physiological or pathological conditions some of the dispensable amino acids can become conditionally indispensable because endogenous synthesis cannot meet metabolic needs.[2] These include: arginine, cysteine, glutamine, glycine, proline and tyrosine.

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Table 1: Recommended Daily Allowance of Indispensable Amino Acids for Adults 19 years and Older[1]

Amino acid	mg/kg/day
Histidine	14
Isoleucine	19
Leucine	42
Lysine	38
Methionine (+ cysteine)	19
Phenylalanine (+ tyrosine)	33
Threonine	20
Tryptophan	5
Valine	24

Once ingested, the low pH of the stomach denatures the protein which is then broken down into peptides by the action of pepsin. After moving into the small intestine, further digestion takes place through the action of pancreatic enzymes, such as trypsin, chymotrypsin and carboxypeptidase, forming free amino acids, dipeptides and tripeptides that can be absorbed. The digestibility of protein can vary. Animal proteins tend to have a higher digestibility (~95%) compared to whole plant foods (~80-85%).[3] However, purified plant protein sources such as soy protein isolate and pea protein concentrate display a digestibility similar to that of animal-based protein sources.[4] Protein sources can also vary significantly in their content of amino acids. A protein is considered complete if it contains an adequate proportion of each of the nine indispensable amino acids (e.g. milk protein). Plant proteins are generally lower in methionine (e.g. legumes) and lysine (e.g. cereals) than animal-based proteins.[5, 6] The indispensable amino acid that is most deficient relative to metabolic needs is referred to as the limiting amino acid within the protein. Similar to a chain's strength being limited by its weakest link, a protein's capacity to meet nutritional needs is limited by its 'most deficient' indispensable amino acid. To overcome the consequence of a limiting amino acid, the amino acid can be fortified as is the case with methionine in soy-based infant formulas. In addition, proteins can be combined to complement their amino acid profiles and provide a more complete protein blend.[5, 6]

Protein quality

Protein digestibility and content of indispensable amino acids are factors that affect protein quality. Over the years, numerous methods have been developed in an attempt to quantify the quality of a given protein. One of the methods, the Protein Digestibility-Corrected Amino Acid Score (PDCAAS), is now widely used as a routine assay for the assessment of the quality of single proteins and protein blends.[7, 8] According to this method, protein quality is assessed by expressing the amount of the first limiting indispensable amino acid in the protein of interest as a fraction of the same amino acid in an 'ideal' reference pattern and then multiplying this amino acid score by the true faecal nitrogen digestibility (%) as determined in rats. Scores exceeding 100% are truncated to 100%. Higher scores reflect a higher quality protein or protein blend.

Protein requirements

The requirement for dietary protein is based on the body's need for nitrogen and indispensable amino acids. Nitrogen is needed for the synthesis of dispensable and conditionally indispensable amino acids, as well as physiologically important nitrogen containing compounds such as nucleic acids. As previously stated, indispensable amino acids cannot be made by human tissues at a rate commensurate with metabolic needs and must be supplied via the diet. Unlike carbohydrate (glycogen) and fat (adipose) stores, whose primary role is energy, the protein lost during fasting or periods of physical stress has a greater negative impact on the body due to the specific and relevant roles that protein plays. During periods of high physical stress, such as illness or hospitalisation, patients become hypercatabolic and may experience a significant loss of muscle protein as a result of anabolic resistance and an increase in muscle protein breakdown.[9] Inadequate protein intake can lead to a negative nitrogen balance resulting in skeletal muscle atrophy, functional decline and poor recoveries.[10]

The administration of high quality proteins (high PDCAAS score) can help mitigate the metabolic loss of protein during periods of physical stress by providing the nitrogen and indispensable amino acids needed by the body for recovery.

According to the Institute of Medicine (2005), adults require 0.8 grams protein/kg body weight/day with requirements being higher for pregnant and lactating women and growing children.[1] There is considerable interest and effort to better understand the protein/amino acid requirements of hospitalised patients, particularly those who are critically ill. Following a review of the literature, researchers concluded that critically ill patients require significant amounts of protein, likely in excess of 1.2 grams/kg body weight/day to maintain protein balance and lean body mass.[11] Current recommendations suggest that that 1.2-1.5 grams protein/kg body weight/day is sufficient for most critically ill patients.[12, 13, 14] The European Society for Enteral and Parenteral Nutrition (ESPEN) recommends from 1.3-1.5 grams protein/kg body weight/day for most critical care patients.[13] The Society of Critical Care Medicine (SCCM) and the American Society of Parenteral and Enteral Nutrition (ASPEN) recommend a protein intake of 1.2-2.0 grams/kg body weight/day. Older patients in intensive care units appear less responsive to lower protein intakes and may require more than 2 grams/kg body weight/day.[15, 16] A systematic review by Hoffer and Bistrian (2012) suggests that 2.0-2.5 grams protein/kg body weight/day is safe and could be optimum for most critically ill patients.[17] While protein recommendations vary for critically ill patients, all are significantly greater than the 0.8 grams/kg body weight/day recommended for healthy adults. Unfortunately, results from an international multicenter observational study show that critically ill adults receive only about 0.6 grams protein/kg body weight/day which is well below the levels recommended by authoritative bodies.[18]

Conclusion

Adequate protein is essential for the recovery of critically ill patients. Due to their condition, protein requirements are substantially higher than those of healthy individuals. In order to meet their demands, increased intakes of high-quality protein blends that can be easily delivered to the patient are warranted. High quality proteins, as indicated by their PDCAAS score, ensure the delivery of a highly digestible protein blend that provides the nitrogen and indispensable amino acids essential for recovery.

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About the author: Dr Garleb is dedicated to the discovery and creation of nutrition technologies that impact health and wellness and improve patient outcomes. Dr. Garleb has 20 patents and over 100 peer reviewed articles, abstracts and reviews to his credit.

Dr Garleb has a Bachelor of Science in Agricultural Sciences, a Master of Science in Animal Sciences and a PhD in Nutritional Biochemistry from the University of Illinois at Urbana-Champaign. He is currently an Adjunct Professor at the University.

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