EDITORIAL

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Beyond Standard Protocols: The Dawn of Personalised Critical Care Nutrition

Medical nutrition therapy (MNT) is essential in managing intensive care unit (ICU) patients. Poor nutritional status can negatively impact patient survival and morbidity due to metabolic stress, profound inflammation and increased proteolysis of body protein. ICU patients are particularly prone to malnourishment, with prevalence rates ranging between 38% and 78%. Research demonstrates that providing optimal nutrition intervention in malnourished critically ill patients has consistently reduced hospital stay length, decreased infection rates, and lowered healthcare costs. During critical illness, increased catabolism leads to significant muscle mass loss, resulting in weakness and challenges in weaning from ventilatory support. To address these challenges, MNT provides essential macronutrients, micronutrients and electrolytes while maintaining metabolic homeostasis.[1]

As MNT is a rapidly evolving field, personalisation of ICU nutrition has become crucial for improving patient outcomes. This personalised nutrition approach helps to avoid the harmful effects of over- or underfeeding while preserving muscle mass. However, implementing personalised nutrition therapy in ICU settings remains in its infancy, i.e. at the "beginning of knowledge". Our ability to objectively measure patients' nutritional requirements and responses to nutritional interventions is still limited, making it challenging to optimise nutrition delivery.[2] Medical nutritional therapy must be customised based on individual patient factors, including their unique characteristics, medical condition, and the metabolic state as they progress from the acute phase of illness through recovery, using detailed analysis of their physical traits (phenotyping) and underlying biological patterns (endotyping).

A thorough nutritional assessment is crucial for identifying malnutrition risks in patients. The Modified Nutrition Risk in Critically Ill (mNUTRIC) score and the Global Leadership Initiative on Malnutrition (GLIM) criteria are widely used tools for evaluating nutritional status. While these tools provide standardised approaches, they have limitations and require ongoing validation research for improvement. The GLIM framework employs a two-step approach: first utilising phenotypic and etiologic criteria for diagnosing malnutrition, then grading its severity. Malnutrition is classified as either moderate (stage 1) or severe (stage 2) based on three key factors: unintentional weight loss percentage, low body mass index (BMI), and degree of reduced muscle mass. Although this consensus aims to standardise malnutrition diagnosis globally and improve clinical outcomes across different healthcare settings, the criteria's sensitivity and specificity in various patient populations still need further validation.[3]

When assessing lean body mass (LBM) at the bedside, healthcare providers have access to various tools, each with advantages and limitations. While available, predictive formulas often show significant variations from actual LBM measurements. More sophisticated methods like Dual-energy X-ray absorptiometry, CT, and MRI scans provide highly accurate results but are impractical for routine bedside use due to cost and logistical constraints. Bioelectric impedance analysis (BIA) has become a more practical and affordable bedside option. However, fluid overload can affect its measurements, though this limitation can be addressed using multifrequency BIA to assess extracellular water surplus. Bedside ultrasonography presents another viable alternative, though its accuracy depends on operator expertise and experience.

Personalised medicine is described as an innovative approach that tailors treatment to the individual characteristics of each patient, integrating molecular and clinical data. It is often used interchangeably with precision medicine, which focuses on individual differences in genetics, environments and lifestyles to create unique treatment plans. Personalised nutrition therapy, rooted in phenotyping and endotyping, presents a more practical approach for critically ill patients

than traditional which is based on specific patient characteristics and metabolic markers. Tailored energy and protein strategies and careful micronutrient management can optimise patient outcomes. Personalized phenotypic assessment enables the determination of patient-specific characteristics and body compositional data, facilitating precise calculations of macro- and micronutrient requirements during both acute illness and rehabilitation periods. The process of endotyping reveals specific disease mechanisms through metabolic marker analysis, which guides the development of targeted nutritional strategies. Metabolic biomarkers, particularly the urea-to-creatinine ratio (UCR), serve as potential indicators for monitoring protein metabolism and predicting clinical outcomes. Individualised energy strategy involves utilising indirect calorimetry (IC) to assess energy expenditure, offering a more accurate measure of individual energy needs. Predictive formulas are less reliable, potentially deviating by up to 1000 kcal/ day from actual needs. While one study showed that IC-guided feeding reduced mortality by 23%, a more recent trial (TICACOS-II) could not confirm this benefit. A key challenge is that IC cannot measure endogenous energy production during the early critical phase, and no reliable bedside method exists for this measurement. VCO^2 measurements can be an alternative when IC is unavailable, though they tend to overestimate energy expenditure. Furthermore, the potential benefits of early nutritional therapy are challenged by evidence suggesting that such intervention may suppress autophagy, increases hyperglycaemia and anabolic resistance.

Critically ill patients experience severe muscle wasting, losing up to 15% of muscle mass within the first week of ICU admission. This rapid deterioration, occurring at approximately 2% per day, leads to ICU-acquired weakness (ICU-AW) in about half of patients and significantly impacts outcomes. Each 1% loss in quadriceps muscle thickness corresponds to a 5% increase in 60-day mortality. The pathophysiology of ICU-AW involves multiple interrelated mechanisms. At its core is a severe protein imbalance driven by three key factors: systemic inflammation and sepsis, which disrupt normal protein homeostasis; impaired insulin/IGF-1 signalling, which reduces protein synthesis through suppressed mTOR activity; and enhanced protein breakdown through upregulated proteolytic pathways.[4] These processes are further exacerbated by immobilisation and mitochondrial dysfunction, creating a cycle of accelerated muscle loss. Understanding these mechanisms is crucial for developing effective interventions to preserve muscle mass in critically ill patients and improve their clinical outcomes.

There is a complex and multifaceted relationship between protein intake and muscle preservation in ICU patients. While muscle mass loss is common during ICU stays, providing high amounts of protein may not be the solution. Studies have shown that although higher protein intake helps reduce muscle loss, it does not necessarily translate into functional benefits. Instead, early resistance training combined with protein intake might be more effective than protein supplementation alone. Recent research has revealed that ICU patients have 60% lower protein incorporation into muscle than healthy individuals, even when they can absorb protein normally. This reduced effectiveness may be attributed to several factors, including anabolic resistance, immobilisation, inflammation, and low muscle ATP levels. These findings highlight several challenges in determining optimal protein dosing: whether to use total body weight or lean mass for calculating daily needs, the lack of validated biomarkers for identifying patients who would benefit from higher protein intake, and the limitations of nitrogen balance measurements, particularly in patients with renal failure.

Further research is needed to develop better methods for assessing muscle anabolism, improving practical measurements of whole-body protein balance, and understanding whether higher protein intake can overcome the anabolic resistance observed in critical illness. Persistent inflammation has been identified as a key factor driving muscle catabolism, as it disrupts the balance between muscle protein synthesis (MPS) and muscle protein breakdown (MPB), favouring the latter. One promising avenue of research involves omega-3 fatty acids, specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These compounds play a crucial role in synthesising specialised pro-resolving

mediators (SPMs), which may help resolve inflammation and promote muscle health. Combining these fatty acids with adequate protein intake could prove more effective than either intervention alone, potentially offering a more comprehensive approach to combat inflammation-related muscle loss and improve clinical outcomes in ICU patients.[5]

Integrating artificial intelligence (AI) in critical care nutrition represents a transformative approach to personalised patient care in the ICU setting. AI systems leverage machine learning algorithms to analyse real-time patient data, including metabolic parameters, laboratory values, and vital signs, enabling personalised nutritional interventions. Through various AI methodologies, including natural language processing, automated monitoring, machine learning and deep learning, these systems can predict energy requirements, assess malnutrition risk, and optimise the timing of nutritional support initiation. While the evidence base continues to develop, AI demonstrates significant potential in processing complex datasets and identifying correlations between nutritional interventions and patient outcomes. Implementation requires addressing multifaceted challenges, including data management, privacy concerns, and financial considerations. AI's capability to analyse diverse data sources facilitates a more responsive approach to patients' evolving needs while accelerating research through improved patient stratification and pattern recognition in feeding protocols. This technological advancement promises to enhance clinical decision-making and streamline documentation processes, ultimately improving patient outcomes through evidence-based MNT in critical care settings. While AI holds promise for enhancing nutrition research and practice, significant gaps in research, ethical considerations, and clinical validation remain.[6]

The evolving landscape of medical nutrition therapy in ICU settings highlights the complexities of nutrition management for critically ill patients. Personalised nutrition therapy tailors treatment based on individual patient characteristics, integrating phenotyping and endotyping. This method involves customising energy and protein strategies according to specific patient data and metabolic markers. Continued research and innovation in personalised approaches, assessment tools and the integration of AI are essential for improving patient care and outcomes in critical care nutrition.

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