Review Article

Incorporating ultrasonography to the nutritional assessment process in intensive care settings to improve the prescription of enteral and parenteral nutrition

Benefits, practicality, and challenges

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ABSTRACT

قد تتعرض صلاحية أدوات التقييم الغذائي التقليدية في أماكن العناية المركزة للخطر عندما يعاني المريض من حالات مثل الوذمة والالتهاب. تعتبر الموجات فوق الصوتية (US) أداة غير جراحية بجانب السرير يمكن استخدامها لتقييم التغيرات في كتلة العضلات. ومن ثم، يمكن US توجيه ممارسي الرعاية الصحية في تحديد الدرجات المختلفة لسوء التغذية وتعديل الوصفة الغذائية وفقًا لذلك. تناقش هذه المراجعة البيانات المتوفرة حاليًا فيما يتعلق بالجدوى والتطبيق العملي لاستخدام القياسات US في العناية المركزة. بشكل عام، تشير البيانات إلى أن استخدام US كجزء من التقييم القياسات البشرية القياسية للمرضى المصابين بأمراض خطيرة هي أداة واعدة لتتبع الاختلافات في كتلة العضلات. وهذا لديه القدرة على تعزيز الوصفات الغذائية وتخصيص توفير البروتين والطاقة للمرضى المصابين بأمراض خطيرة بناءً على قياسات كتلة الجسم النحيلة. ولذلك، يوصى بتدريب أخصائيي التغذية على استخدام US في قياسات تكوين الجسم.

The validity of the traditional nutritional assessment tools in intensive care settings might be compromised when the patient has conditions such as oedema and inflammation. Ultrasound (US) is considered a non-invasive, bedside tool that can be utilized to assess changes in muscle mass. Hence, US could guide healthcare practitioners in identifying the varying degrees of malnutrition and adjusting the nutritional prescription accordingly. This review discusses the currently available data regarding the feasibility and practicality of using US measurements in intensive care settings. Overall, the data suggest that using US as part of the standard anthropometric assessment for critically ill patients is a promising tool to track variations in muscle mass. This has the potential to enhance nutritional prescription and tailor the provision of protein and energy to critically ill patients based on their lean body mass measurements. Therefore, it is recommended to train dietitians on utilizing US for body composition measurements.

Keywords: ultrasound, ICU, muscle wasting, enteral nutrition, parenteral nutrition

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Nutrition is an important component of the management plan for critically ill children and adults. Meeting the energy requirements of critically ill patients is crucial to minimize muscle loss and sarcopenia and improve their overall quality of life.[1] However, ensuring that the nutritional requirements of this group of patients are met is challenging because they undergo several metabolic phases.[2,3] Previous studies have shown that, during acute illness, a series of inflammatory, endocrine, and metabolic changes occur as part of the body's response to the acute insult.[4-6] The combined effect of the inflammatory and metabolic dysregulation along with underfeeding, which is common among critically ill patients, can result in the deterioration of their nutritional status.[7,8] Therefore, practitioners usually rely on a series of nutritional assessment criteria to adjust the nutritional dose and improve the patient's nutritional status.[9,10]

Biochemical and anthropometric data are tools used to assess the patient's nutritional status. However, in intensive care settings, the validity of these parameters might be compromised because of the patient's conditions including inflammation, fluid shifts, and oedema.[11,12] Due to theses complexities,

it might be challenging to obtain precise and reliable anthropometric data in this patient population. Therefore, there is an urgent need for an alternative method to guide healthcare practitioners in identifying the varying degrees of malnutrition and adjusting the nutritional prescription accordingly. Muscle mass is considered a key parameter in guiding the nutritional intervention; thus, being able to measure muscle mass in clinical practice is essential.[13] Based on expert's consensus, it was suggested that using ultrasonography at bedside in intensive care settings is an emerging tool to conveniently measure muscle mass and determine changes in lean body mass, given its availability and ease of use.[14,15] Incorporating ultrasound (US) measurements as part of the standard anthropometric assessment for critically ill patients could be a promising strategy to improve the nutritional prescription in intensive care settings. Therefore, in this review, we aim to discuss the current data regarding the feasibility and practicality of using US measurements in the intensive care unit (ICU) and we also aim to discuss the potential benefits of incorporating US measurements as part of the nutritional assessment process.

Ultrasonication as a nutritional assessment tool in adult and paediatric intensive care settings. Over the past few years, there has been an increasing interest in understanding the possible role of US as a nutritional assessment tool in intensive care settings. Ultrasonography is considered a non-invasive, bedside tool that can be employed to assess changes in muscle mass.[10] As it allows for visualization of muscle thickness and the cross-sectional area and that clinicians to better assess muscle wasting and tailor nutritional interventions accordingly.[13] Ultrasound measurements can be performed serially to detect short-term changes in the adductor pollicis, arm muscle, and thickness of the calf, rectus-femoris, and vastus-intermedius.[16-19] By tracking changes in muscle thickness or cross-sectional area, clinicians can monitor muscle wasting or recovery.

The ultrasonography assessment of the thickness of the quadriceps muscle in critically ill adult patients showed adequate intra- and inter-observer reliability, suggesting that it could be a promising tool for evaluating the effects of the nutritional intervention on muscle wasting or recovery among this patient's group.[17] Fivez et al[18] (2016) assessed the thickness of the thigh muscle in critically ill adults and children and concluded that ultrasonography is a reliable tool for the early detection of muscle wasting in adult patients. However, among children, the reliability of the measurement was compromised. In a later study, Valla et al[19] (2017), they aimed to enhance the accuracy and reproducibility of the US measurement in critically ill children by designing a measurement protocol that involved utilizing anterior thigh ultrasonography along with multiple measurements of quadriceps femoris muscle thickness across different axes. They indicated that measuring the thickness of the quadriceps femoris is a reliable technique for paediatric patients. In another study, ultrasonography was used as an indicator of the nutritional status and disease prognosis patients upon admission to the ICU.[20] Bury et al[21] (2020) described how trained registered dietitians performed US measurements and detected changes in the quadriceps muscle thickness and suggested that this technique could be used to evaluate the loss of lean muscle mass in critically ill patients.

When measuring the thickness of the rectus-femoris muscle, patients should lay in a supine position where the knees should be extended and relaxed to their full extension.[22,23] The probe used generally ranges from 10 to 13 MHz, to ensure optimal acoustic contact, it is important to coat the probe with a water-soluble transmission gel.[22-24] During the measurement, the probe should be aligned perpendicular to the longitudinal and transverse axis of the target muscle.[22,23] The muscle circumference, cross-sectional muscle area as well as the anteroposterior and transversal muscle thickness are the commonly used variables measured by US to assess muscle mass[22] (**Figure 1**).

Tracking the changes in lean-body mass during the ICU stay may help dietitians identify patients at nutritional risk and tailor their nutritional intervention plans accordingly. Kokura et al[25] (2023) highlighted several applications of US that can help intensive care dietitians in providing proper nutritional management. These applications include assessing the nutritional status, evaluating weight loss and muscle wasting, and adjusting the nutritional prescription.[25] In addition, the recent guidelines of the "European Society for Clinical Nutrition and Metabolism" mention that US can be used to evaluate muscle loss in critically ill patients.[3]

Potential benefits of US in improving the nutritional prescription in intensive care settings. Underfeeding is a major problem in intensive care settings, and it is frequently recorded among both critically ill adults and children.[6,8] Research has suggested that bedside

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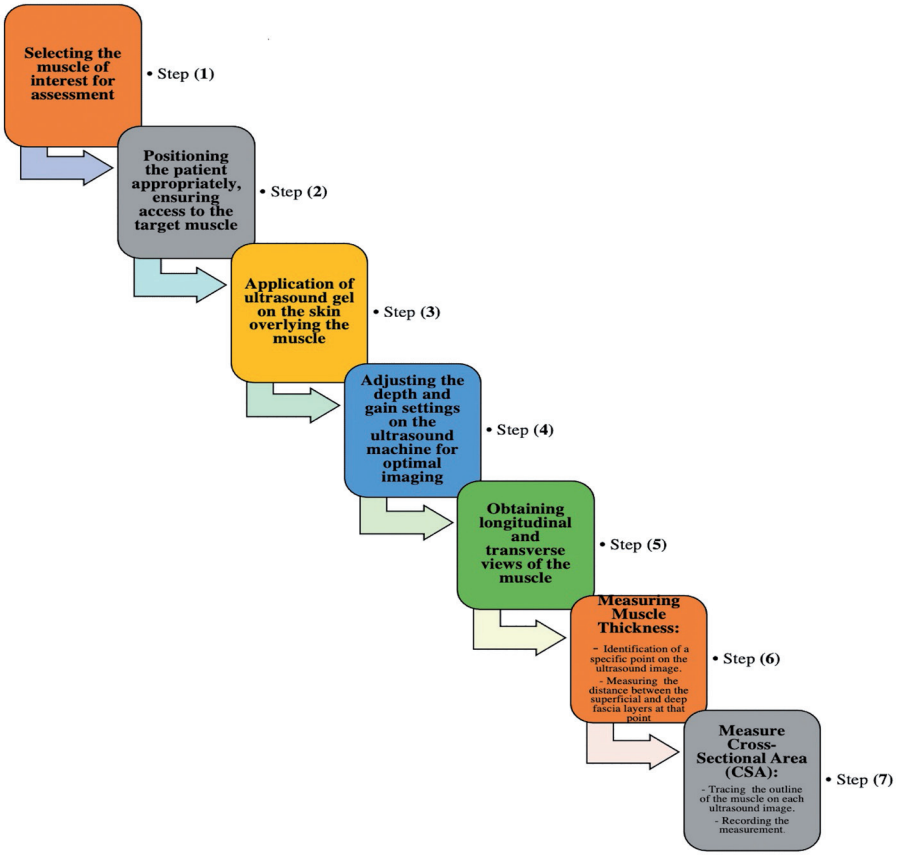

Figure 1 - Steps of assessing muscle mass by ultrasound.

techniques including US measurements of the muscle may help monitor lean mass loss during the ICU stay. Thus, will facilitate individualization of protein intake, modifications of the nutritional support prescription and evaluate the impact of nutritional interventions based on the lean body mass.[17,26] McNelly et al[27] (2020) used changes in the cross-sectional area of the rectus femoris as the primary endpoint measured by US to compare the effects of intermittent enteral feeding versus continuous enteral feeding on muscle wasting among critically ill patients. Another study assessed muscle wasting using US imagining of the thickness of the rectus-femoris and vastus-intermedius muscles of the quadriceps to determine the risk of wasting in haemodialysis patients.[28] In addition, US imagining of the forearm muscle was used to test the effects of different amino acids doses in parenteral nutrition (PN). As a result, the higher amino acid dose was associated with an increase in the thickness of the forearm muscle.[29] Moreover, another study reported that supplemental PN in critically ill patients who could not reach their caloric goal by day 3 after ICU admission was associated with a smaller loss of the rectus-femoris muscle, measured by US and compared to the control group.[30] Umbrello et al[31] (2021) reported that the cumulative protein deficit over 7 days of ICU stay was associated with a decrease in both the rectus-femoris and diaphragm size measured by US among critically ill patients with COVID-19. Valla et al[19] (2017) argued that US measurement of the quadriceps-femoris is a reliable technique for monitoring and guiding nutritional interventions in critically ill children. Overall, these findings indicate that US measurements allow for personalizing the nutritional care plans of critically ill patients and specifically target their needs by optimizing the protein and energy intake to prevent muscle loss and promote recovery. Therefore, it is recommended to train dietitians on utilizing US for body composition measurements.[32]

Practicality and challenges of using US as a nutritional assessment tool in adult and paediatric intensive care settings. Despite the abundant evidence supporting the benefits of routinely using US measurements

as a bedside tool to evaluate the nutritional status of critically ill patients, body composition assessment using US is technically limited in ICU settings and is currently being applied only for research purposes.[10]

Ultrasound is widely available in most intensive care units, it is cost effective, easy to learn and perform, minimally invasive and it is a portable tool that can be performed at the patient's bedside.[21] Bury et al [21] (2020) recommended the use of US by registered dietitians to measure the thickness of the quadriceps muscle to assess muscle loss in critically ill patients. Sabatino et al[33] (2017) also supported this approach, and they suggested that registered dietitians are the key clinicians who could use US to assess lean body mass in critically ill patients. However, the use of US by dietitians is still limited. In a recent survey of members of the "American Society for Parenteral and Enteral Nutrition", which included 439 registered dietitians, only 1% of the participants indicated that they use US in their daily nutritional assessment practice.[34]

In a survey-based study in Japan that investigated the barriers to implementing US as a tool to measure muscle mass indicated that 21% of healthcare practitioners conduct US-based muscle mass measurements, whereas only 6% of dietitians use US for muscle mass assessment.[35] The authors of the Japanese study also reported that the greatest barrier to the implementation and use of US is lack of education.[35] Lack of standardized protocols for assessing muscle mass by ultrasound might be an additional challenge.[36] As this can result in variations in measurement techniques and inconsistency in reporting findings. Developing standardized protocols and reference values specific to the ICU population would enhance the reliability and comparability of ultrasound measurements. Another limitation of using ultrasonography as nutritional assessment tool to monitor the lean body mass is that the accuracy and reliability of US measurements can vary depending on the skill and experience of the clinician.[37] Therefore, it is crucial to establish a standardized training, measurements protocols, and cut-off values specific to different patient populations and clinical conditions.[13]

In conclusion, training registered dietitians on how to use ultrasonography for measuring muscle mass will directly contribute to the overall improvement of the nutrition care process in the ICU. Ultrasound measurements of muscle mass are clinically relevant for guiding nutritional interventions in intensive care settings. Therefore, US measurements of muscle mass should be integrated into the patient's routine nutritional assessment process to adjust their nutrition care plan. Future studies should focus on developing a standardized protocols for assessing muscle by US that incorporate reference values specific to the ICU.

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