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GENERAL INFORMATION

Nutritional assessment in the critically ill patient

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KEYWORDS
Nutritional assessment;
Malnutrition;
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Abstract
Malnutrition is a condition caused by inadequate intake or poor absorption of nutrients and hypercatabolism that occurs in hospitalised patients of all ages, with a prevalence of 20-50% for both surgical and medical causes, impacting the effectiveness of treatments, hospital costs, prognosis, mortality, and hospital stay. The presence of malnutrition or risk of developing it is higher in critically ill patients, ranging between 11 and 80%.
Nutritional assessment systems are significant, reliable, specific and have universal parameters that estimate the nutritional status; they contemplate subjective measures such as subjective global assessment and objective measures: anthropometric, immunological, biochemical, and functional predictors of mortality risk.
In this article we conclude that as subjective global assessment and albumin are reliable parameters and statistically significant indicators of malnutrition accompanied by others such as muscle strength, they bring us closer to a better idea of the patient's nutritional status and the need to administer nutritional support.

PALABRAS CLAVE
Evaluación nutricional;
Desnutrición;
Estado nutricional

Evaluación nutricional en el paciente grave

Resumen
La desnutrición es un estado patológico ocasionado por la falta de ingesta o absorción deficiente de nutrientes, así como por un estado de hipercatabolismo. Se presenta en pacientes hospitalizados de todas las edades, con una prevalencia del 20 al 50%, tanto por causas quirúrgicas como médicas, con repercusión en: la eficacia de los tratamientos, en los costes hospitalarios,

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el pronóstico, la mortalidad y la estancia intrahospitalaria del paciente. La presencia de desnutrición o riesgo de desarrollarla es superior en los pacientes críticos, y oscila entre el 11 y el 80%.

Los sistemas de evaluación nutricional son parámetros significativos, confiables, específicos y universales, para la valoración del estado nutricional, que contemplan medidas subjetivas como la evaluación global subjetiva y medidas objetivas: antropométricas, inmunológicas, bioquímicas y funcionales, como predictores de riesgo de mortalidad y herramientas diagnósticas.

Con base en lo anterior, en este artículo se concluye que en el paciente con trauma múltiple (sepsis, quirúrgico y/o cáncer), la evaluación global subjetiva más la albúmina son parámetros confiables, estadísticamente significativos e indicadores del grado de desnutrición que, acompañados de otros como fuerza muscular, nos acercan a una idea más concreta del estado nutricional del paciente y a la necesidad de administrarle apoyo nutricional.

Background

Malnutrition is a pathological condition where there is a lack of food intake and poor nutrient absorption and hypercatabolic states (surgery, trauma, sepsis, burns) alter homoeostasis (Table 1)[1]. This condition occurs in hospitalised patients of all ages, with a prevalence of 20 to 50%[1], increasing as hospitalisation is prolonged and where protein requirements needed for critically ill surgical patients are 1.25 to 2.5 g/kg/day[1], affecting the effectiveness of treatments in hospital costs, prognosis, mortality and hospital stay.

The issue of malnutrition has been addressed since ancient times and many studies have evidenced the need to establish a definition and estimation parameters of nutritional status. Recent advances in studies into body composition and knowledge of the negative effects of malnutrition on patients have allowed us to establish an association between the nutritional status of the hospitalised patient and the presence of morbidity and mortality, with the aim of applying a suitable treatment that mitigates the potential risk of complications and mortality[2].

According to Tapia Jurado et al.[3] in 1936, Studley showed, in patients who have undergone a gastrectomy for gastric cancer, how a poor nutritional status affects postoperative mortality and concluded that patients with losses >20% of their body weight before surgery had a mortality of 33% compared to those without weight loss, where mortality was 3.5%.

The presence of malnutrition or the risk of developing it is higher in critically ill patients, where prevalence values range between 11 and 80%. The overall effects of protein-calorie malnutrition consist mainly of a reduction in skeletal muscle mass—due to a loss of protein—body fat, water, macronutrients and micronutrients[3], which together compromise the general state and evolution of the critically ill patient.

Meeting the energy requirements of a critically ill patient is not easy but necessary; despite that, nutritional assessment is not always conducted in health institutions because of an absence of specific methods or adequate scales, the time available for health care and the many variables that modify these patients' energy expenditure[3] (Fig. 1). To this we must add a lack of training for medical professionals and limited economic resources for the prevention of this condition in critically ill patients[3].

Currently, multiple studies have determined the nutritional status of the patient by using objective and subjective parameters for the implementation of nutritional support. Despite this, these markers of malnutrition in critically ill patients are not ideal or absolute alone; several must be used together, and even then there is no reliable standard for evaluating the nutritional status in critically ill patients.

Table 1 Causes of malnutrition in surgery

Factors	Cause
Decrease in food intake	Fasting, vomiting, diarrhoea, dysphagia
Reduction of intestinal motility	Paralytic ileus, mechanical obstruction
Presence of inflammation or malignant disease	Inflammatory bowel disease, neoplasias
Surgical stress*	Pain, anaesthesia, sedation, hypothermia, immobility, hypercatabolism, neuromuscular blocking medication
Sepsis*	Local, systemic infection

*Factors that increase energy expenditure in hospitalised patients.

Figure 1 Female patient, 18 years old, who presented with oesophageal perforation after a complication of nasogastric tube placement leading to mediastinitis and severe sepsis with multiple organ failure. After 4 weeks of evolution she presented a loss of 20 kg due to lack of nutritional support.

Nutritional assessment systems

Nutritional assessment systems are quantitative and qualitative, parameters that are meaningful, reliable, specific and universal. However, their application is subject to severe changes that arise from patients' acute illnesses. Treatment measures[4] are grouped into *subjective measures* such as subjective global assessment, and *objective measures such as* anthropometric, immunological, biochemical and functional (Fig. 2).

Subjective global assessment

According to Gómez Candela et al.[5], subjective global assessment (Table 2) is a screening test developed by Detsky et al. in 1987 at the Toronto General Hospital, which is a clinical method of assessing nutritional risk, useful for monitoring the effectiveness of nutritional therapy of a patient through a medical history and physical examination. Although the test was originally designed exclusively for patients undergoing gastrointestinal surgery, it is currently applied in virtually all clinical conditions that can occur in a patient[5].

Subjective global assessment is a cheap, fast, simple, reproducible, clinical parameter that takes an average time of 9 min to conduct. Unlike other nutritional assessment tests, it is the only one that assesses the functional capacity of the patient. It is also useful to determine serum albumin in identifying patients undergoing major abdominal surgery with risk of complications, re-admissions or prolonged hospital stay[5,6]. It consists of determining:

- *Changes in body weight*. This is due to the fact that changes in the last 6 months have a good correlation with the patients' evolution, specifically in weight changes during the last few weeks, that is, if the loss is <5% it is not significant; 5-10%, it is potentially significant and a loss of > 10% of total body weight is significant[6].
- *Changes in diet*. This parameter is used to identify changes in their intake pattern and duration. They are divided into normal or abnormal.
- *Gastrointestinal symptoms*. Its usefulness lies in identifying anorexia, nausea, vomiting and diarrhoea and whether they occur daily for periods lasting >2 weeks.
- *Functional* capacity. Quantifies patient autonomy.
- *Primary disease*. Establishes the degree of the patient's nutritional requirements according to their existing pathology.
- *Physical* examination. It is of great importance because it semi-quantitatively determines a variable that reflects the loss of muscle mass (in quadriceps and deltoids), another that shows the loss of subcutaneous fat (triceps and chest) as well as an indicator of serum protein loss (evident as oedema of the ankles, sacrum or anasarca). Provides categories labelled normal, mild, moderate and severe.

The rating scale allows placing patients into three groups:

A. Patients with adequate nutritional status (normal nutrition).

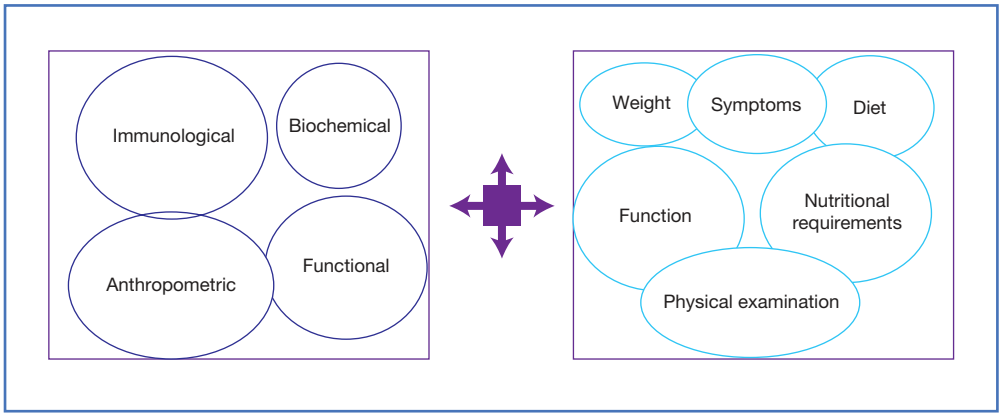

Figure 2 Components of nutritional assessment parameters.

Table 2 Overall nutritional subjective assessment[4]

A. Background				
1. Weight change				
Weight loss in the last 6 months:	kg	% loss		
Changes in the past 2 weeks:	Increase	No change	Decrease	
2. Change in dietary intake (relative to normal):				
No changes				
Changes:	Duration: weeks			
Type:	Suboptimal solid diet	Liquid diet	Low-calorie liquids	Inanition
3. Functional capacity				
No dysfunction	Dysfunction	Duration	Weeks	
Type:	Suboptimal working	Outpatient	In bed	
4. Gastrointestinal symptoms (duration >2 weeks)				
None	Nausea	Vomiting	Diarrhoea	Anorexia
5. Disease and its relation to nutritional requirements				
Primary diagnosis (specific)				
Metabolic demands (stress)				
No stress	Low stress	Moderate stress	High stress	
B. Physical activity:	0 = normal	1 = mild	2 = moderate	3 = intense
Loss of subcutaneous fat (triceps, chest)				
Muscular atrophy (quadriceps, deltoids)				
Ankle oedema				
Sacral oedema				
Ascites				
C. SGA classification (subjective global assessment)				
a: well nourished				
b: moderate (suspected of being malnourished)				
c: severely malnourished				

Based on Marulanda et al.[31].

B. Patients with suspected malnutrition or moderate malnutrition (weight loss of 5-10% in 6 months, reduced intake in 2 weeks and loss of subcutaneous tissue).
C. Patients suffering from severe malnutrition (weight loss >10% in 6 months with oedema and severe loss of subcutaneous and muscle tissue)[6].

Objective parameters of nutritional assessment

These are divided into anthropometric, biochemical, immunological and functional variables.

Anthropometric parameters

Anthropometric variables evaluate and detect malnutrition that exists before admission of critically ill patients. However, body changes (oedema) and the evolution of these patients' hydration status invalidate these variables as parameters of nutritional monitoring and prognosis in critically ill patients.

Included in these is the body mass index (BMI), which is a reliable and accessible parameter, able to assess the relationship between the patient's weight and size. A normal range is considered a BMI between 18.5 and 24.9 kg/m^2; indices of <18.49 kg/m^2 are indicative of malnutrition and associated with a significant increase in mortality in different types of patients[6]. A minority falls into parameters of >29.9 kg/m^2, which reflects a degree of excess weight or obesity.

Another parameter is the triceps skinfold measurement, which is a commonly used procedure able to predict energy reserves and assess the responses of a hospitalised patient to treatment. The usefulness of the triceps skinfold was evidenced in a study as a marker of nutritional status and the inversely proportional relationship between its size and risk of postoperative death[6].

There are other body segments determinations that can be used: among them are the mid-upper arm muscle circumference, heel-knee index or ulna length. All of these are able to estimate this relationship in the case BMI is not used.

Biochemical parameters

As is the case with anthropometric parameters, biochemical variables are interfered with by changes that occur in critically ill patients, so interest in them in interpreting nutri-

tional status is limited[6]. There are multiple parameters used in this area, with the most used being:

- *Creatinine height index*. An indicator of the amount of muscle tissue; a value between 60 and 80% of reference value would suppose a moderate protein depletion, whereas figures of <60% indicate severe protein depletion. In critically ill patients, the creatinine height index lacks prognostic or monitoring value in isolation, but represents a useful tool combined with other nutritional parameters.
- *3-methylhistidine*. An amino acid derived from protein muscle metabolism. Its values increase in hypercatabolic situations and decrease in the elderly and in malnourished patients.
- Nitrogen balance. A good parameter of improvement in postoperative patients with moderate stress or malnutrition. It is used as an index of nutritional prognosis because the passage from negative to positive of nitrogen balance is indicative of an adequate protein intake in the critically ill patient.
- *Albumin*. The most commonly used biochemical parameter in nutritional assessment because it is the main protein synthesised in the liver and constitutes 60% of human serum proteins. It has a circulating half-life of 15 to 20 days, with a replacement of 15 g/day. It provides 70-80% of oncotic pressure and functions as enzymes, hormones, medications and trace elements carrier; it is used in the diagnosis and prognosis of various diseases and is of great prognostic value for the evolution of the critically ill patient's health status where values <3.2 g/dl are associated with increased patient morbidity and mortality (Table 3)[7].

This depletion in albumin levels may result from four main causes: decreased synthesis, increased catabolism, increased loss or alteration in the distribution. Alteration in the distribution of intra- and extravascular albumin is probably the most common cause of oedema in critically ill patients.

In critically ill patients, liver albumin synthesis decreases as a result of reprioritisation for the synthesis of acute phase reactants. Both tumour necrosis factor (TNF) and interleukin 6 are able to depress the albumin gene transcription and its production and an increased albumin catabolism associated with increased corticosteroid generated during the stress response is established; these factors result in the depletion of this serum protein, manifested in biochemical tests of patients in serious condition despite the fact that in an initial state the total rate of degradation decreases as the plasma concentration of albumin does. This compensatory mechanism is not sufficient to maintain homoeostasis in the body.

Table 3 Clinical interpretation of serum albumin*

Serum albumin (g/dl)	Interpretation
≥2.7 <3.2	Slight deficit
≥2.1 <2.7	Moderate deficit
<2.1	Serious deficit

The increased permeability to proteins and other macromolecules in small vessels is a characteristic recognised in septic patients. Direct measurements of albumin permeability show that the transcapillary escape rate of this protein may increase by up to 300% in these patients, coupled with neutrophil activation and cytokine release as well as the change in the integrity of endothelial junctions that change this percentage.

Other proteins such as prealbumin, retinol-bound protein, transferrin, protein C, α-1-antitrypsin, α-1-glycoprotein and haptoglobin are unspecific and their value may be related to the intensity of the metabolic response. However, they cannot be specific on their own as quantifiers of nutritional status.

Functional estimation parameters

Functional estimation parameters such as forearm muscle function tests measured with a dynamometer, both actively (respiratory muscle strength, vital capacity) and passively (response of muscle contraction and relaxation to different electric currents) have been used as indicators of nutritional status and as a predictor of postoperative risk[7] because a loss of muscle mass and its consequent weakness may be due to an increased use of protein reserves at the expense of the catabolism of branched chain amino acids through gluconeogenic routes in patients undergoing prolonged fasting, those who are suffering from malnutrition and those with increased metabolic stress secondary to septic processes or undergoing surgeries[7].

Immunological parameters

A decrease in total lymphocyte count (<1500), CD3/CD4 (<50) index and absence in the delayed cellular immunity response have been linked to malnutrition. In critically ill patients, both the lymphocyte counts and immune function tests may be altered by a large number of clinical situations or the administration of medications used in treatment.

The total lymphocyte count is significant to establishing the nutritional status of the patient because certain nutritive substrates are required for cellular immunity such as amino acids and folic acid. This promotes the synthesis of proteins, antibodies, proliferation and development of myeloid cells as well as a differentiation of B and T lymphocytes (Table 4)[8].

Other tests in nutritional assessment

The *neutron activation analysis*, which calculates the body's total nitrogen; *bioelectrical impedance analysis*, which measures total body water volume, and *potassium isotopes*, used in the calculation of total lean tissue mass, are still experimental techniques of little use in critically ill patients.

We can confirm that both subjective and objective parameters are rarely used in clinical practice due to the wide variety of options available and because the reference margins cannot be extrapolated to all populations as each has its own characteristics specific to country, age, types and changes in diet and disease progression.

Table 4 General reference values for structural, biochemical, immunological and functional diagnosis of nutritional risk in individuals aged 18-59 years[9]

Nutritional parameter	5th percentile
Triceps skinfold (men) (mm)	10
Triceps skinfold (women) (mm)	14
Albumin (g/l)	3.2
Total lymphocyte count (µl)	1,393
Muscle strength (male) (kg/F)	
18-39 years old	
Students	28
Other occupations	30
40-59 years old	25
Muscle strength (women) (kg/F)	
18-59 years old	20

A diagnosis of nutritional risk is established when any of the observed values is ≤ 5th percentile[9].

In Mexico, studies have been conducted that have provided valuable information regarding reference values to identify malnutrition in patients; for example, in 2004, in the Mexican Social Security Institute, XXI Century National Medical Center[8], a cross-sectional, descriptive and prospective study was carried out on a sample of 500 patients aged 18-59 years divided into four groups. The measures taken included central tendency (median and mode), dispersion (standard deviation, variance, etc.) and 5, 25, 50, 75 and 95 percentiles of the following nutritional assessment parameters: triceps skinfold, albumin, total lymphocytes count and non-dominant arm muscle strength (Table 4)[8]. The above parameters were selected because they are aspects where malnutrition most affects human physiology in addition to being common variables in patients, concluding that the values <5th percentile for each age group are indicators of those at nutritional risk.

Certain conditions such as cancer of the digestive tract are associated with protein-calorie malnutrition because of four main causes: effects of inflammation mediators; metabolic response to trauma; mechanical disorders of the tumour, and adverse effects of adjunctive treatments, which have resulted in an increased morbidity and mortality in this group of patients. Strategies have been designed to comprehensively assess the nutritional status of the patient before and during treatment to avoid complications. In 2001 the results of a study conducted at the Hospital of Oncology, XXI Century National Medical Center were published—a prospective cohort, longitudinal, clinical and observational study—where the objective was to determine whether nutritional assessment parameters: triceps skinfold, albumin, total lymphocytes count and arm muscle strength, are useful as prognostic indicators of postoperative morbidity and mortality in cancers of the digestive system. One hundred patients with confirmed cancer were included and those with AIDS, obesity, kidney and liver failure were excluded. They were nutritionally evaluated within 48 h before their operation, were monitored for a period of 30 days after the operation and their presented complications were recorded. The results were analysed with contingency tables for the predictive value of variables, logistic regression test for albumin calculation of relative risk, a confidence interval of 95% and *p* value. Finally, it was noted that the triceps skinfold, total lymphocyte count and arm muscle strength did not produce statistically significant values to predict morbidity and mortality; however, albumin on its own was statistically significant for predicting morbidity ($p = 0.028$) and to predict mortality ($p = 0.004$). The above confirmed that albumin is a prerequisite for all nutritional assessment in surgical patients[8].

In 2006, a multicentre, observational, cross-sectional, prospective, comparative and blind study was developed, initiated by the Mexican Association of General Surgery through their Research Committee, with 234 patients undergoing major non-neoplastic abdominal surgery. The objective of the study was to establish whether subjective global assessment was a reliable parameter for predicting the evolution of surgical patients. It was carried out in four public hospitals and one private hospital in the cities of Mexico, Durango, Tampico and Mexicali[9]. Parametric tests for interval and proportional variables and non-parametric tests for ordinal and nominal variables were performed. It was concluded that the overall clinical subjective assessment, alone or combined with simple biochemical parameters such as serum albumin, represents a fundamental tool because of its speed, low cost and accessibility in the evaluation of severe surgical patients at risk of complications, re-admission or prolonged hospital stay.

Finally, advances in parenteral nutrition in addition to improved techniques for placement of central catheters[10] are noteworthy. They have facilitated the treatment and prevention of malnutrition by intravenous infusion of nutrients; however, we must remain alert to the metabolic complications of parenteral nutrition and catheter-related sepsis.

Furthermore, in the septic patient, malnutrition is a state of energy, protein or some other specific nutrient deficiency that produces a measurable change in body function associated with a poor outcome of the disease and increased risk of complications and mortality, but it can be reversed by nutritional support[11].

Currently, malnutrition and its timely identification in hospitals are a necessity[12]. Regional nutritional status have been evaluated in multiple research studies because Mexican reference values are different from those in the literature of English-speaking countries; moreover, there has been an interest in finding nutritional parameters that can provide guidance on the status, evolution and the best treatment to use in these severely ill patients[13].

Malnutrition is a serious complication in diseaseevolution. For example, in cancer patients, its prevalence ranges from 15-20% at the time of diagnosis and increases to 80-90% in advanced cases of the disease[14,15]. The causes of malnutrition in cancer and septic patients are related to seven mediators[16] of inflammation such as cachexin or TNF-α. These are mainly synthesised by macrophages in response to various invasive stimuli, causing alterations in the metabolism of nutritional substrates, electrolyte imbalance, immune and endocrine disorders, and metabolic response to trauma where it occurs with protein-calorie demands that exceed intake, despite adaptation to acute or chronic fasting[17,18].

Furthermore, metabolic and neuroendocrine response to surgical trauma or underlying disease[19] promotes increased nutrient demands, leading the patient to manifest such simple changes in medical status, decreased muscle tone and strength, changes in serum albumin, total lymphocyte counts and triceps skinfold measurement, among others[20].

At the moment it is considered that subjective global assessment is the best parameter to assess the patient's nutritional status because of its clinical approach, which includes dietary habits, symptoms, functional ability and physical examination, which are all easy to obtain[21].

Furthermore, albumin is considered important due to its association with multiple diseases, postoperative evolution and as a prognostic factor[22] where the relation that is inversely proportional between a value of ≤3.2 g/dl and an increase of complications and in turn mortality has been documented[23].

The importance of including the quantification of muscle strength lies in showing the degree of protein malnutrition and functional capacity of the patient in everyday life[24,25]. Adequate nutritional status enables optimisation of the patient's immune response against the aggression of pathogens, both in septic processes and external to them, neoplasias or post-surgery. In cases where there is no such condition it is important to assess the degree of immune compromise to predict complications and disease progression[26]. Finding nutritional disorders in the subjective global assessment, serum albumin and in non-dominant arm strength measured by a dynamometer strongly suggests to us a prognosis risk of mortality and morbidity. In such clinical cases, the right decision is to indicate preoperative enteral or parenteral nutritional support, if feasible (in regard to surgical conditions of the patient), or administering it at an early postoperative stage, which would reduce morbidity and mortality in the severely malnourished patient[7].

The assessment of a person's nutritional status is a complex process that can be facilitated by approximate, indirect (subjective) and accurate (objective) indicators[28], which together provide an overall idea of the patient's nutritional status in order to prevent complications, mortality, and provide appropriate nutritional support treatments[29,30].

Conclusions

Malnutrition is a condition present in most hospitalised patients as a causal factor for complications and increased mortality.

Nutritional assessment is a system of subjective and objective variables designed to establish universal, reliable, specific parameters in order to identify patients at risk of or who are suffering from malnutrition, in favour of establishing an appropriate nutritional support.

Patients in hospital, critical, post-surgical, oncology and septic units represent a group at high risk of malnutrition due to their underlying disease so it is important to conduct a detailed clinical history, physical examination with subjective global assessments and measurement laboratories (parameters of objective evaluation) which can identify them.

Finally, we can say that albumin is a statistically significant and reliable parameter, an indicator of the degree of malnutrition which, together with other elements such as muscle strength and subjective global assessment, is an effective, cost effective and simple nutritional assessmentto set up in all hospitals.

Conflict of interest

The authors declare no conflict of interest.

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