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Accuracy of nutritional assessment tools for predicting adverse hospital outcomes

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Abstract

Background and aims: **The ability of nutritional status assessment methods to predict clinical outcomes in hospitalized patients has not been completely evaluated. This study compared the accuracy of traditionally used nutritional tools and parameters in predicting death, infection, and length of hospital stay (LOS) in hospitalized adults.**

Research Methods & Procedures: **Patients admitted at clinical and surgical wards were evaluated by body mass index, percentage of weight loss, Subjective Global Assessment, albumin, lymphocyte count, and followed until discharge. Clinical outcomes considered were in-hospital death, infection, and LOS. Overall accuracy of each method to predict these outcomes was assessed from ROC curves and C-statistic.**

Results: **Among 434 patients evaluated, 51% had a prolonged LOS, 23% developed infection, and 7.8% died during hospitalization. In univariate analysis, serum albumin was the strongest predictive parameter for death (C-statistic: 0.77; $CI_{95\%}$: 0.69-0.86) and hospital infection (C-statistic: 0.67; $CI_{95\%}$: 0.61-0.74). For longer stay, lymphocyte count (C-statistic: 0.60; $CI_{95\%}$: 0.55-0.65) emerged as the most predictive variable. After adjustment for non-surgical hospitalization and cancer diagnosis, weight loss > 5% (OR: 1.58; $CI_{95\%}$: 1.06-3.35), and serum albumin < 3.5 g/dL (OR: 2.40; $CI_{95\%}$: 1.46-3.94) were associated to LOS. Albumin was the only independent variable related to infection (OR: 5.01; $CI_{95\%}$: 3.06-8.18) and, for hospital death, albumin (OR: 7.20; $CI_{95\%}$: 3.39-15.32) adjusted for age (OR: 1.03; $CI_{95\%}$: 1.01-1.06).**

Conclusions: **Nutritional assessment methods evaluated were weakly predictors of hospital outcomes. Except for low serum albumin, isolated use of these methods adds little information in identifying the effect of nutritional status on clinically relevant outcomes.**

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Key words: *Nutritional status. Malnutrition. Inpatients. Risk assessment. Serum albumin.*

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FIABILIDAD DE LOS INSTRUMENTOS DE VALORACIÓN NUTRITIVA PARA PREDECIR UNA MALA EVOLUCIÓN CLÍNICA EN HOSPITALIZADOS

Resumen

Conocimientos previos y objetivos: **No se ha evaluado de forma completa la fiabilidad de los métodos de evaluación del estado nutritivo para predecir la evolución clínica de los pacientes hospitalizados. Este estudio comparó la precisión de instrumentos tradicionales y de parámetros en la predicción de muerte, infección y duración de hospitalización (DH) en adultos hospitalizados.**

Métodos de investigación y procedimientos: **Se evaluó a pacientes ingresados en guardias médicas y quirúrgicas, empleando el índice de masa corporal, el porcentaje de pérdida de peso, la Valoración Subjetiva Global, la albúmina y el recuento linfocitario, y se les siguió hasta ser dados de alta.**

Resultados: **Entre los 434 pacientes evaluados, el 51% tuvo una DH prolongada, el 23% desarrolló infección y el 7,8% murió durante la hospitalización. En el análisis de univarianza, el factor predictivo de muerte más potente fue la albúmina sérica (C-estadística: 0,67; $IC_{95\%}$: 0,61-0,74) y también de infección hospitalaria (C-estadística: 0,67; $IC_{95\%}$: 0,61-0,74). En el caso de una mayor DH, la variable predictiva más fiable fue el recuento linfocitario (C-estadística: 0,60; $IC_{95\%}$: 0,55-0,65). Tras realizar el ajuste de hospitalización no quirúrgica y diagnóstico de cáncer, la pérdida de peso > 5% (OR: 1,58; $IC_{95\%}$: 1,06-3,35) y la albúmina sérica < 3,5 g/dl (OR: 2,40; $IC_{95\%}$: 1,46-3,94) se asociaban a la DH. La albúmina fue la única variable independiente relacionada con la infección (OR: 5,01; $IC_{95\%}$: 3,06-8,18) y, en el caso de muerte hospitalaria, la albúmina (OR: 7,20; $IC_{95\%}$: 3,39-15,32) ajustada en función de la edad (OR: 1,03; $IC_{95\%}$: 1,01-1,06).**

Conclusiones: **Los métodos de valoración nutritiva evaluados fueron predictores débiles de la evolución clínica hospitalaria. Exceptuando la albúmina sérica baja, la determinación aislada de estos parámetros añade poca información para identificar el efecto del estado nutricional sobre la evolución clínica.**

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Palabras clave: *Estado nutritivo. Malnutrición. Pacientes hospitalizados. Valoración de riesgo. Albúmina sérica.*

Introduction

Malnutrition is a prevalent syndrome in hospitalized patients, corresponding to approximately 50% of hospitalized adults worldwide.[1-4] It has been associated with clinical complications, increased morbidity and mortality,[1-3,5] length of hospital stay (LOS),[4,6] hospitalization costs[7] and poor quality of life.[8]

Several methods, both subjective and objective, of greater or lesser complexity and costs, are available for assessing nutritional status. In practice, body mass index, percentage of weight loss, and subjective global assessment are those most frequently employed. Laboratory data, such as lymphocyte count and serum albumin, despite the fact that may be altered by several acute clinical conditions, are still implemented as parameters of nutritional status.[9-12] Unfortunately, there is no single method adopted as a standard reference to assess nutritional status. The acceptance of such methods in clinical practice, for the whole spectrum of hospitalized adults, is limited due to the lack of adequate validation studies, use of subjective criteria,[13] restriction to selected patient groups,[14] low feasibility, and need for highly trained personnel.

In the absence of validated parameters, the American Society of Parenteral and Enteral Nutrition (ASPEN) recommends the use of clinical and biochemical parameters to confirm the presence of malnutrition.[15] More recently, assessment methods of nutritional status have been developed and their ability to predict outcomes associated with malnutrition or the overall individual health status has been increasingly studied.[16-24] However, data on the influence of the nutritional status on clinically relevant outcomes has been inconsistent and inconclusive.

The purpose of this study was to compare the accuracy of body mass index (BMI), percentage of involuntary weight loss in 6 months (WL), subjective global assessment (SGA), serum albumin and lymphocyte count in predicting death, infection and LOS in a heterogeneous group of hospitalized adults.

Materials and methods

Patients

From existing databases that previously addressed the prevalence of malnutrition in adults (patients older than 18 years of age) hospitalized at medical and surgical wards in a 749-bed University Hospital, 434 patients were included in the present study (185 assessed in 2002 and other 249 assessed in 2004). Patients from the intensive care units, bone marrow transplant unit, with obstetric admission, those with amputated members, using casts, and those who could not provide information on their clinical status nor be able to be submitted to anthropometric methods were not enrolled in the original databases, therefore were not included in the present study. The study was approved by the Research and Ethics Committee of the Institution.

Nutritional Assessment Methods

The nutritional assessment was performed during hospitalization and included the following methods: BMI,[25] %WL,[26] SGA,[27] albumin and serum lymphocyte count. Assessment was carried out by Nutrition university students, previously trained and under supervision. The same research protocol and assessment routine was adopted for all patients. The SGA was performed first, followed by measurement of body weight and height. Body weight was measured using electronic platform scales with a maximum load of 200 kg and increments of 100 g. Height measurements were taken by means of fixed anthropometers available at hospital wards. Both scales and anthropometers are checked and certified on an annual basis by the National Institute of Weights and Measurements.

Laboratory tests (albumin and serum lymphocyte count) were ordered at the discretion of the medical teams, without interference from the investigators. For the lymphocyte count and for serum albumin, only values obtained within 72 hours and 7 days from nutritional assessment were included, respectively.

Hospital Outcomes

Three outcomes evaluated were in-hospital death, infection, and LOS, all collected from review of electronic patients' records. A prolonged LOS was defined as a hospitalization longer than 15 days. Hospital infection was considered as being any infection acquired and diagnosed during hospitalization, despite its site of origin. The hospital medical teams performed all infection diagnoses and these data were obtained from the medical records. Patients with more than one episode of infection were categorized as having ongoing infection, not taking into account the site or severity of the episodes.

Data Analysis

Continuous and normally distributed data are presented as mean ± standard deviation (SD), those without normal distribution as median and interquartile intervals, and categorical ones as a percentage.

Some patients did not have albumin levels (n = 205) or lymphocyte count (n = 29) measured within the studied period. For these patients, median levels in this sample, which coincidently matched the lower reference values (3.5 g/dL and 1,500 U/µL, respectively) were included. According to SGA, patients were classified in three categories: a) well nourished, b) moderately (or suspicion) malnourished, and c) severely malnourished, as described by Detsky et al.[13]

Other nutritional parameters were evaluated as continuous variables and stratified by median values. Since most of these variables have established reference values for malnutrition, they were dichotomized at the

Table I
Patient characteristics and nutritional assessment parameters. Data expressed in n (%), unless otherwise specified

	N = 434
Age (years)	56.4 ± 16 [a]
Age ≥ 65 years	154 (35.5%)
Male gender	223 (51.4%)
Time of hospitalization before assessment (days)	6 (3-12) [b]
Time of hospitalization before assessment	
0-7 days	261 (60.1%)
8-14 days	98 (22.6%)
15-21 days	36 (8.3%)
≥ 22 days	39 (9%)
Non-surgical admission	233 (53.7%)
Cancer	169 (38.9%)
Nutritional variables	
Subjective Global Assessment	
Nourished	212 (48.8%)
Suspicious/moderate malnutrition	83 (19.1%)
Severe malnutrition	139 (32%)
Percentage of weight loss (%)	-5 (-12.7– -0.2) [b]
Percentage of weight loss >5%	216 (49.8%)
Body Mass Index (kg/m²)	23.9 (21.1-27.9) [b]
Body Mass Index (Kg/m²)	
< 18,5	46 (11.1%)
18.5 ⊢– 25	207 (47.7%)
≥ 25	179 (41.2%)
Lymphocyte count (U/µL)	1,500 (1,060-1,950) [b]
Lymphocyte count ≤ 1,500 U/µL	249 (57.4%)
Albumin (g/dL)	3.5 (3.5-3.6) [b]
Albumin < 3.5 g/dL	99 (22.8%)

[a] = mean ± standard deviation; [b] = median (interquartile intervals).

following cutoff points: BMI < 18.5 kg/m², WL > 5% in 6 months, albumin < 3.5 g/dL and lymphocytes ≤ 1,500 U/µL. The results obtained using nutritional variables dichotomized by median or reference values were similar. Dichotomization using reference values was chosen in order to facilitate comparisons with other studies.

The accuracy of the different methods to predict death, infection and LOS was evaluated by plotting ROC curves and by estimating the C-statistic. For each outcome a multivariate logistic regression was performed using the «enter» method, including all those variables that in the univariate analysis had a p value < 0.25 (Wald's test). Variables that in the model presented p values < 0.05 (Wald's test) were retained, while those with a higher p value were removed, one at each time. No significant interactions were identified among predictive variables and any outcome. Pre-defined subgroups analysis was carried out for the presence of cancer, surgery patients, and age ≥ 65 years old. The linearity assumption of the function between continuous variables and each outcome was also tested.

The initial hypothesis was that subjects classified according to SGA as malnourished (suspicious or moderate, and severe) would present the worst clinical outcomes: death, infection and LOS. Therefore, considering a value of $\alpha = 0.05$ and comparing the frequencies obtained in this study for death, infection, and hospital stay in malnourished and nourished patients, this study has power of 85%, 75% and > 95% for these outcomes, respectively.

All analyses were performed in the SPSS 10.0 statistical software and p values < 0.05 (two-tailed) were considered statistically significant.

Results

The study population consisted of 434 patients, 51% were male, and 36% were 65 years or older. In 46% of patients, the underlying reason for hospitalization was surgical, and 39% were diagnosed with cancer (table I). The average hospitalization length of stay was 15 days (P25: 8.8-P75: 26), and 51% had been hospitalized for a period equal to or greater than 15 days, 23% presented hospital infection, and 7.8% died.

Using different diagnostic criteria, a wide variability in malnutrition prevalence was observed, ranging from 11% according to BMI < 18.5 kg/m² to 57.4% for a lymphocyte count ≤ 1,500 U/µL (fig. 1).

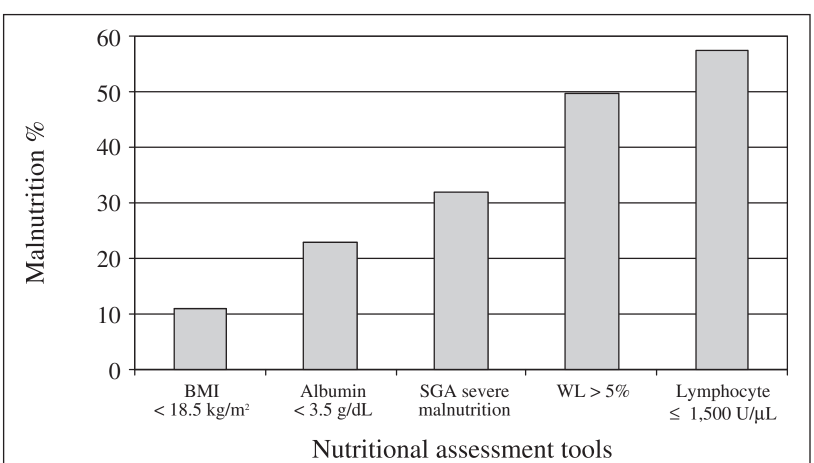

Fig. 1.—Malnutrition prevalence according to each nutritional assessment parameter. BMI - body mass index; SGA = subjective global assessment; WL = percentage of involuntary weight loss.

Table II
Univariate predictors of death, infection and prolonged hospital stay

Variable	*Death*		*Infection*		*LOS*	
	OR (95% CI)	*p*	*OR (95% CI)*	*p*	*OR (95% CI)*	*p*
Age (years)	1.04 (1.01-1.07)	< 0.01	1.01 (0.99-1.02)	0.34	1.01 (0.99-1.02)	0.31
Male gender	1.22 (0.60-2.46)	0.59	1.24 (0.79-1.93)	0.35	0.99 (0.68-1.44)	0.95
Non-surgical admission	1.64 (0.80-3.41)	0.19	1.22 (0.78-1.91)	0.39	1.88 (1.28-2.76)	< 0.01
Cancer	2.41 (1.18-4.51)	0.02	1.43 (0.91-2.24)	0.12	1.69 (1.14-2.49)	< 0.01
SGA (A)	1.0		1.0		1.0	
(B)	2.72 (0.99-7.51)	0.05	1.55 (0.85 – 2.84)	0.16	1.31 (0.79-2.18)	0.30
(C)	3.79 (1.60-8.99)	< 0.01	1.98 (1.20-3.28)	< 0.01	1.86 (1.20- 2.86)	< 0.01
BMI < 18.5 kg/m^2	1.61 (1.45-7.64)	< 0.01	2.43 (1.30-4.55)	< 0.01	1.47 (0.80-2.69)	0.21
Lymphocytes ≤ 1,500 U/μL	3.33 (0.76-3.89)	0.21	1.73 (1.09-2.76)	0.02	1.65 (1.13-2.43)	0.01
Weight loss > 5%	1.95 (0.94-4.04)	0.07	1.75 (1.11-2.76)	0.02	1.88 (1.29-2.76)	< 0.01
Albumin < 3.5 g/dL	7.69 (3.65-16.22)	< 0.01	5.01 (3.06-8.18)	< 0.01	2.77 (1.71-4.47)	< 0.01

(A) well-nourished; (B) suspicious or moderate malnutrition; (C) severe malnutrition.

In univariate analyses, age, cancer diagnosis, BMI < 18.5 kg/m^2, severe malnutrition defined by SGA, and serum albumin < 3.5 g/dL were associated with increased hospital death. Severe malnutrition diagnosed by SGA, BMI < 18.5 kg/m^2, lymphocytes ≤ 1,500 U/μL, WL > 5% and serum albumin < 3.5 d/dL were associated with infection, whereas hospitalization due to non-surgical reasons, cancer diagnosis, severe malnutrition by SGA, low lymphocytes count, WL > 5%, and serum albumin < 3.5 g/dL were associated to prolonged LOS (table II). The individual predictive accuracy of each method to identify each outcome is summarized in table III. Although most variables were statistically significant, overall values showed a weak ability to predict each outcome.

Upon adjustment for confounding factors through multiple logistic regression, low serum albumin (OR: 7.2; $CI_{95\%}$: 3.4-15.3) adjusted by age was significantly associated to death, whereas serum albumin < 3.5 g/dL (OR: 5.0; $CI_{95\%}$: 3.1-8.2) was the only independently variable significantly associated to infection. As well, serum albumin < 3.5 g/dL (OR: 2.40; $CI_{95\%}$: 1.5-4.0), adjusted by hospitalization due to clinical reasons, cancer diagnosis and WL > 5%, was significantly associated to LOS (table IV).

Discussion

In the present study, low serum albumin, adjusted for other confounding variables, was the nutritional assessment method with greatest accuracy in predicting death, infection, and hospital stay in adults admitted to clinical and surgical wards.

Some studies point to malnutrition as a risk factor for death, infection and LOS. However, many have not been planned to assess the predictive performance of the methods employed[23,28-31] and the choice of method was exclusively under the judgment of the investigator. As an example, in a study evaluating the efficacy of parenteral nutritional therapy to reduce post-operative complications, SGA, albumin serum levels and Nutritional Risk Index (NRI) were the methods selected for monitoring nutritional status of 395

Table III
Accuracy of nutritional parameters for LOS, infection and hospital death, expressed in an area under the ROC curve (95% CI)

Variable	*Death*	*Infection*	*LOS*
SGA	0.65 (0.60-0.74)*	0.58 (0.52-0.65)*	0.57 (0.52-0.62)*
Lymphocytes (U/μL) #	0.61 (0.51-0.72)*	0.61 (0.54-0.68)*	0.60 (0.55-0.65)*
WL (%) #	0.65 (0.55-0.75)*	0.59 (0.52-0.65)*	0.57 (0.51-0.62)*
BMI (kg/m^2) #	0.55 (0.43-0.67)	0.59 (0.52-0.65)*	0.57 (0.51-0.62)*
Albumin (g/dL) #	0.77 (0.69-0.86)*	0.67 (0.61-0.74)*	0.52 (0.46-0.57)

* $p < 0.05$; # continuous variables; BMI = body mass index; LOS = prolonged length f stay; SGA = Subjective Global Assessment; WL = percentage of weight loss.

Table IV
Multivariate logistic regression models for each outcome: a) hospital death, b) infection, and c) hospital stay ≥ 15 days

Model	*Death*	*Infection*	*Prolongued LOS*
Age (years)	1.03 (1.01-1.1)		
Albumin < 3.5 g/dL	7.2 (3.4-15.3)	5.0 (3.1- 8.2)	2.4 (1.5-4.0)
Non-surgical admission			2.1 (1.4-3.2)
Cancer			1.7 (1.2-2.6)
Weight loss > 5%			1.6 (1.1-3.4)
C-statistic	0.79 (0.70-0.87)*	0.66 (0.60-0.73)*	0.68 (0.63-0.73)*

LOS = length of stay.

malnourished patients submitted to laparotomy and thoracotomy.[28] In fact, both the SGA[29,32] and the NRI[33] are used to assess the nutritional status and to predict hospital infection in non selected clinical and surgical patients, despite the fact that they have been validated in single centers studies with restricted and selected group of patients.[13]

The absence of a consensus towards a gold standard and specific criteria for the recommendation on the type of test to be used[15] predisposes to considerable variability in the prevalence rates of hospital malnutrition. While BMI[34,35] and serum albumin tend to underestimate the prevalence of malnutrition,[36] SGA on the other hand seems to overestimate it.[37] The same is anticipated with the percentage of weight loss since it is an important component within the instrument of SGA.

Albumin is probably the biochemical marker of nutritional status most often used, especially in surgical patients, in spite of the limitation imposed by its long half-life (20 days) and the fact that it is influenced by the presence of inflammatory diseases, or other severe clinical conditions, such as trauma and stress[14] or other conditions related to the disease or even to the therapeutic procedures.[38,39] Perhaps for this reason there is not a consensus on the validity of the use of serum albumin as a parameter for nutritional diagnosis.[40-42] Despite of that, serum albumin levels < 3.5 g/dL were associated to an increase in hospital complications, length of hospitalization, and hospital mortality.[14,43-47] In a study that assessed 12 patient strata, pooled according to clinical characteristics, submitted to parenteral nutrition, Llop et al.[48] found that a serum albumin below 3.5 g/dL at the onset of treatment was a predictor of kidney and liver failure, hospital infection, and mortality in some of the 12 assessed subgroups.

The association between hypoalbuminemia and clinical outcomes in surgical patients is more consistent in the literature. In Gibbs' study,[14] among 54,215 subjects, in 54 U.S. tertiary Veterans hospitals, serum albumin concentration proved to be the most accurate marker for identifying 30-day mortality and morbidity post surgery. Other variables such as age, *American Society of Anesthesiologists Score* (ASA), functional state and urgency have also been identified as surgical risk factors, whereas other markers of the nutritional status have not been identified in the presented models.

While assessing 96 patients submitted to elective urology and gynecology surgical procedures, Anderson et al.[49] observed that low albumin had a sensitivity of 22% and a specificity of 91% in predicting hospitalizations lasting more than 10 days, and a sensitivity of 10% and a specificity of 86% for complications. However, the small number of prolonged hospitalizations and complications, and the selected clinical profile of patients raise difficulties in generalizing these findings.

Comparison of the predictive performance between methods of nutritional status assessment where one of them is selected as a gold standard is not an innovative approach.[32,37,50,51] The methodological consistency throughout development and validation of isolated methods, or scores, for the assessment of the nutritional status must be critically appraised before they can be used in clinical practice. In a recent review, Jones evaluated 44 different instruments used for screening and assessment of the nutritional status and confirmed methodological inadequacies in almost all of them[52]. The author suggests the use of available instruments only if they had undergone methodological validation procedures,[53,54] with adaptation for the target population.[55] Thus, there is still need for standardization of the criteria for nutritional classification and for development and validation of easy-applicable, accurate, low cost instruments.

In this study, 17% of patients were assessed after 15 or more days after admission. This may had contributed to a worse nutritional status, as 50% of our patients presented weight loss greater than 5%. In fact, it is possible that the markers of nutritional status and outcomes studied had been influenced by the length of stay and by diagnostic and therapeutic interventions performed during hospitalization.[49,50,56] Even though patients in our study were assessed at any given moment of the hospitalization (median = 6 days), in prior studies, a similar prevalence of malnutrition has been described in the literature.[7,10,57,58] Despite the high frequency of missing values, the strategy of substituting it by the median value had already been used,[59] as in the present study. It is reasonable to assume that this replacement may have little effect on the results, since only patients with serum albumin < 3.5 g/dL were classified as "malnourished" by this biochemical criteria. It is also reasonable to assume that patients to whom physicians did not order the exam more likely presented values higher than 3.5 g/dL, which would not modify the risk found in the multivariate analysis.

Establishing a relationship between malnutrition and hospital death may be a difficult task due to the enormous range of factors that contribute to such outcome. The presence of infection, also influenced by malnutrition, may itself be a cause of hospital mortality. In order to understand the contribution of each variable in this complex process and assess the role of changes in the nutritional status due to hospitalization, it is important to design a study in which patients are monitored and followed all the way from admission to discharge from the hospital.

Conclusion

The methods adopted for assessment of the nutritional status appeared to be weak predictors of death, infection, and hospital stay. Except for low serum albumin, isolated use of these methods adds little information in identifying the effect of nutritional status on clinically relevant outcomes.

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