Nutrición Hospitalaria

Original

Assessing risk screening methods of malnutrition in geriatric patients; Mini Nutritional Assessment (MNA) *versus* Geriatric Nutritional Risk Index (GNRI)

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Abstract

Introduction: Elderly subjects are considered a vulnerable group and they have more risk of nutritional problems. The risk of malnutrition increases in hospitalized geriatric patients.

Objectives: To compare the correlation between MNA and GNRI with anthropometric, biochemical and Barthel Index in hospitalized geriatric patients and to test the concordance between MNA and GNRI and between Mini Nutritional Assessment Short Form (MNA-SF) and MNA.

Methods: It was a cross-sectional study on a sample of 40 hospitalized geriatric patients. For determination nutritional status we used MNA and GNRI; we evaluated the correlation between this both test with biochemical and anthropometric parameters and functional questionnaires. We used Pearson's simple correlation model, one-way ANOVA and multiple logistic regression to evaluate the relationship between MNA and GNRI.

Results: According to MNA, 17 patients (42.5%) were malnourished and according to GNRI, 13 patients (32.5%) had high risk of nutritional complications. The concordance of MNA and GNRI was 39% and between MNA-SF and MNA was 81%. The most significant differences were detected in weight, BMI, arm and calf circumference and weight loss parameters. Barthel index was significantly different in both tests. The MNA and GRNI had significant correlations with albumin, total protein, transferring, arm and calf circumference, weight loss and BMI parameters.

Conclusions: In conclusion, it would be reasonable to use GRNI in cases where MNA is not applicable, or even use GRNI as a complement to MNA in hospitalized

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EVALUACIÓN DE LOS MÉTODOS DE CRIBAJE DE RIESGO NUTRICIONAL EN PACIENTES GERIÁTRICOS; MINI NUTRITIONAL ASSESSMENT (MNA) *VERSUS* GERIATRIC NUTRITIONAL RISK ASSESSMENT (GNRI)

Resumen

Antecedentes: La población anciana esta considerada como un colectivo vulnerable a sufrir problemas nutricionales. Entre estos, los ancianos hospitalizados tienen aun un mayor riesgo a sufrir malnutrición.

Objetivos: Los objetivos de este estudio fueron comparar el grado de correlación entre dos índices de cribaje nutricional, el Mini Nutritional Assessment (MNA) y el Geriatric Nutritional Risk Index (GNRI) con los parámetros antropométricos, bioquímicos, el índice de Barthel y ciertas patologías relacionadas con el estado nutricional (infecciones y úlceras por presión).

Metodología: Se llevó a cabo un estudio transversal en una muestra de 40 pacientes hospitalizados en una unidad geriátrica de agudos. Para la determinación del estado nutricional se usaron los índices del MNA y el GNRI. Se evaluó la correlación entre los parámetros bioquímicos, antropométricos, parámetros funcionales y problemas nutricionales relacionados con la malnutrición (úlceras por presión y infecciones). Para el modelo de correlación, se utilizó el grado de correlación de Pearson; para estudiar la relación entre los índices nutricionales (MNA y GNRI) y los diferentes parámetros se utilizó un análisis de la varianza y un modelo de regresión logística.

Resultados: De acuerdo con el MNA, 17 pacientes (42,5%) estaban desnutridos y de acuerdo con GNRI, 13 pacientes (32,5%) tenían alto riesgo de complicaciones nutricionales. La concordancia de la MNA y la GNRI fue del 39% y entre MNA-SF y MNA fue de 81%. Las diferencias más significativas se detectaron en el peso, el IMC, el brazo y circunferencia de la pantorrilla y los parámetros de pérdida de peso. El MNA y GRNI mostró correlaciones significativas con la albúmina, proteínas totales, la transferencia, la circunferencia del brazo y de la pantorrilla, con el % de pérdida de peso y el índice de masa corporal (IMC). Los pacientes malnutridos según el MNA y los pacientes con riesgo elevado según el GNRI tenían mayor riesgo de sufrir úlceras por presión.

elderly patients. There is no reason why they should be deemed incompatible, and patients could benefit from more effective nutritional intervention.

Conclusiones: en conclusión, sería razonable utilizar el GNRI en los casos en que el MNA no fuera aplicable, o incluso utilizar GNRI como complemento al MNA en pacientes ancianos hospitalizados. No hay ninguna razón por la cual se deban considerar incompatibles, y los pacientes podrían beneficiarse de una intervención nutricional más efectiva.

Introduction

The elderly are considered one of the most heterogeneous and vulnerable groups, with an increased risk of imbalances, deficiencies and nutritional problems.[1-4] Physiological and social changes resulting from advanced age, high consumption of drugs, chronic illness and/or degenerative loss of mobility, psychological distress and loss of appetite are just some of the factors that influence the nutritional status of this group.[5-11] The consequences of malnutrition in the group result in an increase in the prevalence of infections, longer-stay hospitalizations and increased morbidity and mortality.

Malnutrition is not readily recognizable or distinguishable from the changes of the aging process, which means that a significant percentage of cases are undiagnosed.[12] Indicators for diagnosing risk of malnutrition include nutritional parameters, anthropometric, haematological, biochemical and health conditions and associated diseases.[13] There are many indices for assessing nutritional status in the elderly population, though the method recommended by the European Society of Parenteral and Enteral Nutrition (ESPEN) is the Mini Nutritional Assessment (MNA).[14-17] The MNA is the method most commonly used for assessing the nutritional status of older people. It was designed to evaluate and identify those elderly people who are malnourished or at risk of same, in order to intervene as soon as possible and improve their prognosis.[18] A short form of MNA exists (MNA-SF) which is used with malnutrition screening tests. We should bear in mind that it is not applicable to those patients diagnosed with dementia or other communication problems.[16] However, the difficulty in achieving a regular size or weight in patients has resulted in the use of an index devised to investigate and predict complications related to nutritional status in the elderly: the Geriatric Nutritional Risk Index (GNRI).[19,20]

The GNRI index is a modification of the NRI (Nutritional Risk Index)[21] in which the value of "normal weight patients" replaces the original formula of "ideal weight patients" (calculated from Lorentz's formula) to be applied in the geriatric population.[19] This index takes into account two main parameters: serum albumin and the ratio between the current weight and ideal weight of the individual. GNRI formula is structured to give greater weight to plasma albumin than to patients' weight and cut-off points are used to predict health problems in the subsequent months.[20]

The aim of this study is to compare the correlation between MNA and GNRI with anthropometric, biochemical, functional status measure (Barthel Index) and nutritional relation complications (such as infection and bedsores) in a sample of older subjects admitted to hospital. The second objective was to test the concordance between these two methods of assessment and between MNA short form and complete MNA.

Materials and methods

We performed a single centre cross-sectional study on a sample of 40 consecutive acute geriatric patients admitted during the three-month study period (February 2010-April 2010). The study was performed at the Acute Geriatric Ward (AGW) of the University Hospital of Bellvitge, Spain. The study included all patients over the age of 74 who were admitted to the AGW. Exclusion criteria were: the presence of well-known liver disease, neoplasic disorders or terminal condition. At the time of admission to the AGW, each patient was evaluated for the presence of diseases associated with nutritional status (dyslipidemia, diabetes, pressure ulcers and high blood pressure).

Blood samples were obtained within 24-48 hours after admission for determination of serum proteins (albumin, total proteins, C-reactive protein), renal function parameters (creatinine) and other biochemical parameters (iron, ferritin, transferrin, hematocrit and haemoglobin).

Experienced operators collected anthropometric data: weight (to the nearest 0·1 kg using the same calibrated scale), standing height or knee-height (for stature prediction in the bedridden) and mid-upper arm and calf circumferences (to the nearest 0.5 cm using a flexible tape). Estimated height (EH) was extrapolated from knee-heel length according to the equations validated by Chumlea et al.[22] Body mass index (BMI) was calculated for all patients. Ideal body weight, necessary for GNRI determination, was derived by using the following equations of Lorentz:

*Ideal weight for men = height (cm) – 100 [(height – 150/4)]

*Ideal weight for women = height (cm) – 100 [(height – 150/2,5)]

Weight loss in the previous three months was estimated by interviewing patients and family members of each patient.

Mini Nutritional Assessment

The MNA is based on 18 items, including anthropometric and dietary parameters. It is used to assess functional status in elderly patients and to predict mortality.[23-25] Baseline nutritional status was defined and graded according to MNA and MNA-SF. This tool consists of eighteen questions grouped in four rubrics addressing the areas of anthropometry (BMI, weight loss, mid-upper arm and calf circumferences), general state (medication, mobility, presence of pressure ulcers, lifestyle, and presence of psychological stress or neuropsychological problems), dietary assessment (autonomy of feeding, quality and number of meals, fluid intake) and self-perception regarding health and nutrition, respectively. A maximal score of thirty points is achievable on this questionnaire, while threshold values are set as follows: adequately nourished, MNA ≥ 24; at risk of malnutrition, MNA between 17-23·5; and protein-energy malnourished, MNA < 17.

Geriatric Nutritional Risk Index

Nutritional risk of health complications was assessed by the GNRI score through the equation of Bouillanne et al.:[13]

$$GRNI = 1,519 \times Albumin\,(g/l) + 41.7 \times \frac{current\,weight\,(kg)}{ideal\,weight\,(kg)}$$

Categorization of the patients was performed according to the following cut-offs: severe/moderate risk, < 92; low risk, 92-98; no risk > 98. In the present study we utilized the modification proposal devised by Cereda et al.[26] The category of moderate risk (GNRI 92 to 98) and severe risk (GNRI < 92) have been included in one single category because these two categories have been shown to present a similar increased risk (OR) of overall health complications and of those other than mortality (bedsores or infections). Furthermore, this categorization enables us to obtain a three-category tool similar to the MNA.

Barthel Index

The Barthel Index (BI) consists of 10 items that assess the patient's ability to perform certain activities without help. It evaluates abilities such as feeding self, moving from wheelchair to bed and returning, doing one's personal toilet, getting on and off toilet, bathing self, walking on level surface, ascending and descending stairs, dressing, controlling bowels and controlling bladder. Scoring ranges from 0 (completely dependent) to 100 (completely independent) and includes the categories of response between 2 and 4 alternatives, with intervals of 5 points.[27]

Statistical analyses

Data are presented as mean values and standard deviations. We evaluated the relationship between the variables and both the MNA and GNRI using Pearson's simple correlation model, and we compared groups for quantitative variables using one-way ANOVA. Control for overall type I error was performed using the Bonferroni post hoc comparison test. Patients were categorized and a severity score was assigned according to nutrition state based on the MNA (MNA < 17 = 0; 17-23, 5 =1; ≥ 24 = 2) and to nutrition risk as defined by the GNRI (GNRI < 92 = 0; 92-98 = 1, ≥ 98 = 2). We used the χ^2 (Chi squared test) or Fisher's exact test (used when expected values were < 5) to compare prevalence between nutritional classes and Cohen's kappa test to analyse the agreement between the assessment methods. To evaluate the association with the presence of disease related to nutritional status (bedsores) of both these tools, we calculated OR and 95% CI; for each calculation, the unexposed patients were those with a severity score = 2 (GNRI ≥ 98 and MNA ≥ 24, respectively). In addition, we carried out multiple nominal logistic regression analyses to test independent associations. All statistical analyses were performed by SPSS 16.0 (2008, SPSS, Inc, Chicago, IL). The level of significance was established as a two-sided p-value = 0.05.

Results

Baseline characteristics

The sample comprised 29 (72.5%) female and 11 (27.5%) men with a mean (± SD) age of 84.6 (± 5.59) and 83.45 (± 7.91) years, respectively. The major cause of hospitalization was acute heart failure (45% of cases) and exacerbation of chronic pulmonary disease (15%). The most commonly associated comorbidity were: hypertension (80%), pressure ulcers) (35%), dyslipidemia (32.5%), diabetes (25%) and depression (15%).

Nutritional assessment scores

The scores for each patient in the MNA and GNRI can be observed in figure 1. Statistical analyses showed differences in the scores of each group. The groups with the lowest scores were those with worse prognosis
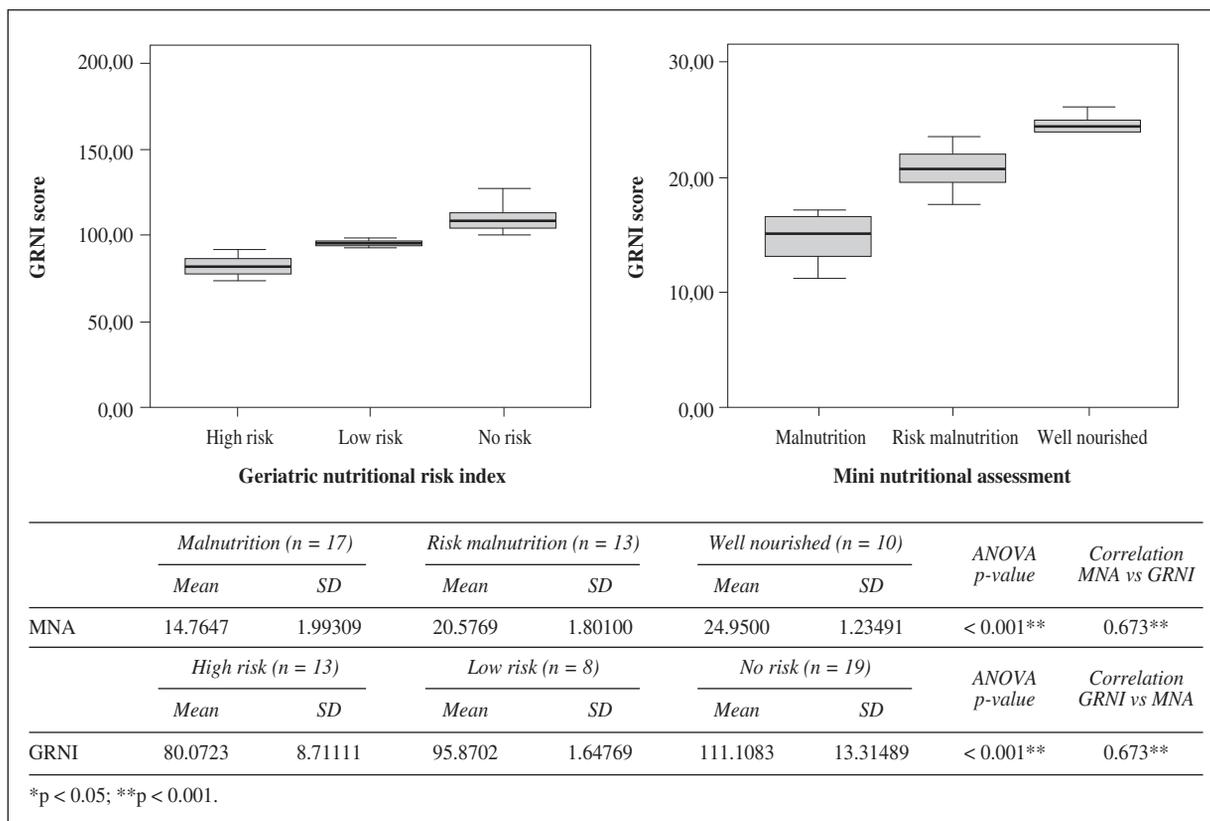
Fig. 1.—Scores for the two nutritional risk assessments. Geriatric Nutritional Risk Index (GNRI) and Mini Nutritional Assessment (MNA).

The figure table:

	Malnutrition (n = 17)		Risk malnutrition (n = 13)		Well nourished (n = 10)		ANOVA p-value	Correlation MNA vs GRNI
	Mean	SD	Mean	SD	Mean	SD		
MNA	14.7647	1.99309	20.5769	1.80100	24.9500	1.23491	< 0.001**	0.673**
	High risk (n = 13)		Low risk (n = 8)		No risk (n = 19)		ANOVA p-value	Correlation GRNI vs MNA
	Mean	SD	Mean	SD	Mean	SD		
GRNI	80.0723	8.71111	95.8702	1.64769	111.1083	13.31489	< 0.001**	0.673**

*p < 0.05; **p < 0.001.

and risk of malnutrition in the MNA and GNRI (fig. 1). According to the MNA, 17 patients (42.5%) were malnourished, 13 patients (32.5%) were at risk of malnutrition and 10 (25%) were well-nourished. According to the GNRI test, 13 patients (32.5%) had high risk of complications related to nutrition, 8 patients (20%) had moderate risk of complications and 19 patients (47.5%) were not at risk of nutritional complications. Although both tests have good correlation (r = 0.673, p = 0.002), discrepancies exist in the classification of patients. The concordance of both tests was approximately 39% (Kappa index = 0,393, p-value = < 0,001) (table I). However, the concordance between MNA short form and complete MNA was 81% (k = 0,810, p-value = < 0,001) (table II).

Biochemical, anthropometric and functional parameters

Results of a one-way analysis of variance and analysis of linear correlation between anthropometric,

Table I
Distribution of the population among nutritional classes according to the Mini Nutritional Assessment (MNA) and the Geriatric Nutritional Risk Index (GNRI)

		MNA vs GRNI			
		MNA			
		Malnutrition (MNA < 17)	Risk malnutrition (MNA 17-23.5)	Well nourished (MNA > 24)	Total[a,b]
GRNI					
High risk (< 92)	n	11 (64.7%)	1 (7.7%)	1 (10.0%)	13 (32.5%)
Low risk (92-98)	n	5 (29.4%)	3 (23.1%)	0 (0.0%)	8 (20.0%)
No risk (> 98)	n	1 (5.9%)	9 (69.2%)	9 (90.0%)	19 (47.5%)
Total	n	17 (100.0%)	13 (100.0%)	10 (100.0%)	40 (100.0%)

[a]Exact Fisher's Chi square = 23.553, p-value = < 0.001.
[b]Kappa index = 0.393, p-value = < 0.001.

Table II

Distribution of the population according to the Mini Nutritional Assessment Short Form (MNA-SF) and complete Mini Nutritional Assessment (MNA)

| | *MNA short form vs MNA* | | | |
	Malnutrition (MNA < 7)	*Risk malnourished (MNA 8-11)*	*Well nourished (MNA > 24)*	*Total[a,b]*
MNA				
Malnutrition (MNA < 17)	16 (84.2%)	1 (8.3%)	0 (10.0%)	17 (42.5%)
Risk malnourished (MNA 17-23.5)	3 (15.8%)	10 (83.3%)	0 (0.0%)	13 (32.5%)
Well nourished (MNA > 24)	0 (0.0%)	1 (8.3%)	9 (100.0%)	10 (25.0%)
Total	19 (100.0%)	12 (100.0)	9 (100.0%)	40 (100.0%)

[a]Exact Fisher's Chi square = 55.331, p-value = < 0.001.
[b]Kappa index = 0.810, p-value = < 0.001.

biochemical and Barthel indexes and the MNA and GNRI are presented in tables III and IV. Data on serum proteins showed that about 42.5% of patients had albumin and total protein concentrations lower than the normal range, and 95% of patients had higher concentrations of C-reactive protein. Markers of protein malnutrition (albumin and total protein) were significantly different for different groups of MNA and GNRI scores. Patients that were malnourished or at risk had lower values in serum protein concentrations. In the case of GNRI, differences were also observed in transferrin levels between the three groups (tables III and IV).

Regarding the anthropometric parameters, significant differences were detected in the parameters of arm and calf circumference, weight and body mass index (BMI) in the MNA, and in GNRI significant differences in the parameters of calf and arm circumference and BMI. In all cases, patients with optimal nutritional status had values greater than the risk groups and/or diagnosis of malnutrition. We also found that the weight loss parameter was significant between the groups according to MNA and GNRI. In both cases, weight losses were higher in the groups that showed lower values in the nutritional assessment scores (tables III and IV).

The score on the Barthel index was significantly different in both tests, MNA and GNRI. The Tukey test showed that in MNA the differences were established

Table III

Statistical description of Mini Nutritional Assessment (MNA) categories, according to Pearson's simple correlation model and one-way ANOVA

MNA	*Malnutrition (n = 17)*		*Risk malnutrition (n = 13)*		*Well nourished (n = 10)*		*ANOVA p-value*	*Correlation r*
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*		
Age (years)	85.06	6.21	84.00	6.40	83.40	6.55	0.791	-0.111
Weight (kg)	57.62	15.74	67.23	9.64	68.84	9.43	0.049*	0.224
Arms circumference (cm)	24.15	3.81	28.47	3.50	27.52	2.70	0.042*	0.416*
Calf circumference (cm)	29.75	3.54	32.30	1.75	33.21	3.25	0.012*	0.445**
Weight loss (kg)	10.78	6.16	4.71	3.99	2.90	4.20	0.001**	-0.553**
BMI (kg/m²)	21.10	4.32	26.85	4.48	27.34	4.95	0.012*	0.318*
Albumin (g/l)	30.00	4.92	34.23	4.57	34.80	4.92	0.021*	0.401*
Total protein (g/l)	62.14	6.60	67.71	5.98	67.09	6.88	0.048*	0.326*
C-reactive protein (mg/l)	96.21	69.26	97.92	93.02	75.14	64.10	0.739	-0.102
Creatinine (µmol/l)	89.88	43.18	102.08	32.79	129.40	71.99	0.144	0.308
Iron (µmol/l)	11.56	6.90	10.98	4.58	18.23	16.79	0.166	0.243
Ferritin (µg/l)	261.10	258.08	209.95	160.25	136.80	87.21	0.298	-0.250
Transferrin (µmol/l)	23.10	4.48	25.09	4.96	27.67	4.75	0.063	0.371*
Hematocrit	0.33	0.06	0.37	0.05	0.33	0.04	0.069	0.043
Hemoglobin (g/l)	109.24	19.57	121.54	17.96	109.70	12.98	0.140	0.058
Barthel Index	55.00	32.21	81.85	19.04	70.00	33.50	0.050*	0.245

*P < 0.05; **P < 0.001.

Table IV
Statistical description of Geriatric Nutritiona Risk Index (GNRI) categories, according to Pearson's simple correlation model and one-way ANOVA

GRNI	High risk (n = 13)		Low risk (n = 6)		No risk (n = 19)		ANOVA p-value	Correlation r
	Mean	SD	Mean	SD	Mean	SD		
Age (years)	86.31	6.54	82.25	6.11	83.79	6.01	0.318	-0.165
Weight (kg)	57.08	17.75	65.18	11.27	67.29	9.06	0.095	0.227
Arms circumference (cm)	23.02	6.28	27.03	4.57	28.45	2.50	<0.001**	0.607**
Calf circumference (cm)	30.36	4.78	30.43	2.62	32.62	2.84	0.098	0.317**
Weight loss (kg)	12.18	6.23	8.31	4.83	2.56	1.94	<0.001**	-0.714**
BMI (kg/m^2)	19.32	2.76	24.12	3.66	28.26	4.12	0.006**	0.488**
Albumin (g/l)	29.15	5.01	31.63	3.07	35.32	4.62	0.002**	0.533**
Total protein (g/l)	59.90	4.09	66.46	8.35	68.27	5.70	0.001**	0.535**
C-reactive protein (mg/l)	87.71	62.18	122.58	71.66	81.00	84.59	0.425	-0.057
Creatinine (μmol/l)	80.77	43.37	114.00	35.17	115.11	56.70	0.136	0.293
Iron (μmol/l)	10.95	7.18	11.88	5.19	14.95	12.85	0.517	0.182
Ferritin (μg/l)	287.07	287.99	199.06	81.30	169.03	146.94	0.255	-0.260
Transferrin (μmol/l)	22.58	4.93	23.65	1.95	26.99	5.10	0.029*	0.406**
Hematocrit	0.33	0.05	0.34	0.06	0.36	0.05	0.340	0.235
Hemoglobin (g/l)	108.69	19.25	110.50	18.88	117.74	16.90	0.347	0.228
Barthel Index	58.85	32.16	49.38	38.03	81.00	19.51	0.019*	0.347*

*P < 0.05; **P < 0.001.

between the at-risk group of patients (81.85 points on the Barthel scale) and the group of patients classified as malnourished (55 points on the Barthel scale); in the GNRI test, significant differences were established between the group of patients at no risk (81 points on the Barthel scale) and patients at high or low risk (58.85 and 49.38 points respectively on the Barthel scale) (tables III and IV).

We evaluated the correlation between the biochemical and anthropometric parameters, and the functional disability assessment (Barthel index) for each of the nutritional screening tests. As shown in tables III and IV, both the MNA and GNRI have significant correlations with the parameters of albumin, total protein, transferrin, arm and calf circumference, weight loss and BMI. Moreover, the GNRI correlated with the Barthel index. In both tests, the highest correlations were observed for weight loss (r = -0.714 and r = -0.553, p < 0.001), serum albumin concentration (r= 0.533 and r = 0.401, p < 0.05)

and arm circumference (r = 0.607 and r = 0.416, p < 0.05) in GNRI and MNA, respectively.

Moreover, it was observed that patients classified as malnourished (according to MNA) or with high risk (according to GNRI) had a higher risk of bedsores. According to GNRI, high risk patients had OR: 17.77 (CI 95%: 2.98-45.91) *versus* patients without risk; according to the MNA, the malnourished patients had an OR: 7.58 (CI 95%: 1.30-43.9) compared to well nourished patients (table V).

Discussion

Our results show that the cross-classification of MNA and GNRI revealed some discrepancies in classification of the patients. In the GNRI index, we only distinguished between three categories: "high risk" (score < 92), "low risk" (score 92-98) and "no risk"

Table V
OR and 95% inteval confidence for besores in patients with high risk and low risk (GNRI) and malnutrition or risk malnutrition (MNA)

GNRI[a]	OR confidence interval 95%				MNA[b]	OR confidence interval 95%			
	p-value	OR	Lower limit	Upper limit		p-value	OR	Lower limit	Upper limit
High risk	0.002	17.778	2.984	45.918	Malnutrition	0.024	7.583	1.309	43.922
Low risk	0.077	5.333	0.834	34.092	Risk malnutrition	0.190	0.194	0.017	2.248

[a]Reference category: no risk.
[b]Reference category: well nourished.

(score > 98) to compare both indexes. In fact, MNA has a greater tendency to diagnose patients as being at risk or malnourished than GNRI does; we found that the level of concordance is almost 40%. According to the present results, and despite the significant relationship between the MNA and GNRI, these tools appeared to perform differently, also showing moderate/poor agreement in grading nutritional status. These results are similar to those obtained by Cereda et al.;[26] in this case they obtained almost 30% of agreement between MNA and GNRI. This poor agreement might be explained by the fact that although both indexes are related, they are measuring different outcomes. Both assessment tools (MNA and GNRI) have been introduced by their authors as methods that can easily and reliably assess patients' nutritional status and assess complications risk in relation to illness often associated with malnutrition, respectively.[18,20]

Both tools showed good ability to discriminate hospitalized patients at risk of malnutrition (according to some anthropometric and biochemical parameters). Biochemical parameter markers are an attractive option in assessing nutritional status, because they are easy to determine and to standardize in clinical practice.[17] In agreement with the results found in other studies, the MNA appeared to be strongly associated with biochemical parameters such as albumin and total protein.[19,28-32] In fact, patients classified as "malnourished" have albumin and total protein levels lower than other patients. In the same way, the GNRI has also been associated with albumin, and total protein parameters; moreover, the correlation coefficients between these parameters and the GNRI index were much higher than the correlation with MNA. These results appear to be logical considering that albumin has an important and specific weight in the GNRI index, unlike MNA. Although results show a relationship between albumin and both indexes, this should be interpreted with caution because this parameter can be modified in patients by an inflammatory process, hydration status, or hepatic and renal impairment.[33-36] Nevertheless, it has considerable prognostic impact and is probably related to poor dietary habits.[28,29,37,38] Additionally, some authors dispute the role of transferrin in detecting malnutrition in old patients.[28] In our study we found a significant correlation between the GNRI index and plasma transferrin, in contrast to previous studies.[28,39] This is probably because other factors may have influenced the serum levels of transferrin; for example, transferrin levels are increased in cases of anaemia and decreased in cases of hepatic cirrhosis, iron overload or acute infections.[39] Thus, the role of transferrin should be evaluated as a marker of nutritional status.

Anthropometric parameters such as weight, BMI, calf and arm circumference and weight loss can reflect functional decline in older adults and should be included in indexes for assessing nutritional status of elderly hospitalized patients.[13-15,17,40] We found that both GNRI and MNA are related to calf circumference, arm circumference, weight loss and body mass index according to nutritional status. The relationship between anthropometric parameters and both indices has been evaluated in other studies, to find similar results.[18,29,40-43] Weight loss (> 5%) in the previous three months has been one of the most significant parameters that affect the nutritional status, and showed an inverse strong correlation with both indexes: the higher the weight loss, the worse scores on both indices. This association has been observed by several authors between MNA[26,44] and GNRI.[26] It is reasonable to argue that the stronger association is probably related to the high weight given to this parameter in both indexes; in addition, several studies have shown that weight loss increased the risk of morbidity and mortality.[45] Calf circumference represents an anthropometric parameter of muscle mass, and provides valuable information on muscle-related disability and physical function.[46] In our study, we found that calf and arm circumference was correlated with both-with GRN but mainly with MNA, according to several authors.[26,40,41] These results suggest that simple and low-cost parameters such as the anthropometric types are probably valid parameters for estimating nutritional status in elderly hospitalized patients and classifying patients according to risk of morbidity and mortality.

GNRI is not an index of malnutrition, it is a "nutrition related" risk index because GNRI scores are correlated to a severity score that takes into account nutrition status- related complications such as bedsores and infections.[19] Bedsores were the only complications taken into account in our study. Patients with high risk in GNRI, risc (Odds Ratio) were significantly higher than that of unexposed subjects (No risk > 98), and the present results agree with the reports of Bouillane et al.[19] and Jiménez Sanz et al.[47] Though MNA is not an indicator of risk of morbidity, we found an association similar to the GNRI: the group of malnutrition patients has an OR significantly higher than the well-nourished group (MNA > 24). Malnutrition has been recognized as a risk factor for the onset and perpetuation of pressure sores.[48-50] According to several studies[26,51,52] we found that low BMI, low serum albumin, weight loss, calf and arm circumference and Barthel index were significantly associated with an increased risk of pressure sores (data not shown). It is very difficult to identify and measure all risk factors for bedsores in clinical routine, but the timely determination of nutrition status or related risk with MNA or GNRI respectively (which includes risk factors like mobility, loss of weight, albumin levels and anthropometric parameters) could identify patients at risk of developing pressure ulcers, and could be assessed quickly and efficiently.

The main limitation of our study is the size of sample, as well as the lack of gold standard for the diagnosis of malnutrition; consequently, a new study will take place in the future to collect a larger sample, and will include other clinical units to assess whether we find similar results to those observed in the present study.

Conclusions

The European Society of Parenteral and Enteral Nutrition (ESPEN) recommends the MNA as the criterion standard in the identification of malnutrition in elderly patients; however, it should be noted that MNA is not a suitable tool for patients who cannot provide a reliable self-assessment (advanced dementia, aphasia or apraxia) or in those cases that patients have parenteral or enteral nutrition. The GNRI is not an index of malnutrition, it is a "nutrition related" risk index. Currently, after this preliminary comparison, it would be reasonable to use GNRI in cases where MNA is not applicable, or even use GNRI as a complement to MNA in hospitalized elderly patients. One possible serious GNRI application could be to use it as a tool for the detection of nutritional risk in patients with chronic pathologies followed in a Health Primary Center or could be useful in nursing homes.

Thus the two methods have their respective advantages and disadvantages; there is no reason why they should be deemed incompatible, and patients could benefit from more effective nutritional intervention. The fact that our results showed a high correlation between the MNA and MNA-SF suggests to us that the MNA-SF can be used as a nutritional screening tool, as it can be performed quickly.

References

1. Mühlethahaler R, Stuck A, Minder C, Frey B. The prognostic significance of protein energy malnutrition in geriatric patients. *Age Ageing* 1995. 24: 193-197.
2. Flodin L, Svensson S, Cederholm T. Body mass index as a predictor of 1 year mortality in geriatric patients. *Clin Nutr* 2000; 19: 121-125.
3. Cereda E, Pedrolli C, Zagami A, Vanotti A, Piffer S, Opizzi A, Rondanelli M, Caccialanza R. Body mass index and mortality in institutionalized elderly. *J Am Med Dir Assoc* 2011; 12: 174-178.
4. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. *Clin Nutr* 2008; 27: 5-15.
5. Engel JH, Siewerdt F, Jackson R, Akobundu U, Wait C, Sahyoun N. Hardiness, depression, and emotional well-being and their association with appetite in older adults. *J Am Geriatr Soc* 2011; 59: 482-487.
6. Timpini A, Facchi E, Cossi S, Ghisla MK, Romanelli G, Marengoni A. Self-reported socio-economic status, social, physical and leisure activities and risk for malnutrition in late life: a cross-sectional population-based study. *J Nutr Health Aging* 2011; 15: 233-238.
7. Toffanello ED, Inelmen EM, Minicuci N, Campigotto F, Sergi G, Coin A, Miotto F, Enzi G, Manzato E. Ten-year trends in vitamin intake in free-living healthy elderly people: the risk of subclinical malnutrition. *J Nutr Health Aging* 2011; 15: 99-103.
8. Mudge AM, Ross LJ, Young AM, Isenring EA, Banks MD. Helping understand nutritional gaps in the elderly (HUNGER): A prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. *Clin Nutr* 2011; doi:10.1016/j.clnu.2010.12.007
9. Jürschik P, Torres J, Solá R, Nuin C, Botigué T, Lavedán A. High rates of malnutrition in older adults receiving different levels of health care in Lleida, Catalonia: an assessment of contributory factors. *J Nutr Elder* 2010; 29: 410-422.
10. Torres SJ, McCabe M, Nowson CA. Depression, nutritional risk and eating behaviour in older caregivers. *J Nutr Health Aging* 2010; 14: 442-448.
11. Skarupski KA, Tangney C, Li H, Ouyang B, Evans DA, Morris MC. Longitudinal association of vitamin B-6, folate, and vitamin B-12 with depressive symptoms among older adults over time. *Am J Clin Nutr* 2010; 92: 330-335.
12. Volkert D, Saeglitz C, Gueldenzoph H, Sieber CC, Stehle P. Undiagnosed malnutrition and nutrition-related problems in geriatric patients. *J Nutr Health Aging* 2010; 14: 387-392.
13. Malnutrition Advisory Group (MAG). MAG—guidelines for Detection and Management of Malnutrition. British Association for Parenteral and Enteral Nutrition, 2000, Redditch, UK.
14. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M; Educational and Clinical Practice Committee, European Society of Parenteral and Enteral Nutrition (ESPEN). ESPEN guidelines for nutrition screening 2002. *Clin Nutr* 2003; 22: 415-421.
15. Morely JE. Anorexia, body composition, and ageing. *Curr Opin Clin Nutr Metab Care* 2001; 4: 9-13.
16. Donini LM, Savina C, Rosano A, Cannella C. Systematic review of nutritional status evaluation and screening tools in the elderly. *J Nutr Health Aging* 2007; 11: 421-432.
17. Soeters PB, Reijven PL, van Bokhorst-de van der Schueren MA, Schols JM, Halfens RJ, Meijers JM et al. A rational approach to nutritional assessment. *Clin Nutr* 2008; 27: 706-716.
18. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. *Nutr Rev* 1996; 54: S59-65.
19. Bouillanne O, Morineau G, Dupont C, Coulombel I, Vincent JP, Nicolis I et al. Geriatric Nutritional Risk Index: a new index for evaluating at-risk elderly medical patients. *Am J Clin Nutr* 2005; 82: 777-783.
20. Cereda E, Pedrolli C. The Geriatric Nutritional Risk Index. *Curr Opin ClinNutr Metab Care* 2009; 12: 1-7.
21. Buzby GP, Knox LS, Crosby LO, Eisenberg JM, Haakenson CM, McNeal GE et al. Study protocol: a randomized clinical trial of total parenteral nutrition in malnourished surgical patients. *Am J Clin Nutr* 1988; 47 (2 Suppl.): 366-381.
22. Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60 to 90 years of age. *J Am Geriatr Soc* 1985; 33: 116-120.
23. Persson M, Brismar K, Katzarski K, Nordenström J, Cederholm T. Nutritional status using mini nutritional assessment and subjective global assessment predict mortality in geriatric patients. *J Am Geriatr Soc* 2002; 50: 1996-2002.
24. Ödlund Olin A, Koochek A, Ljungqvist O, Cederholm T. Nutritional status, well being and functional ability in frail elderly. Service flat residents. *Eur J Clin Nutr* 2005; 59: 263-270.
25. Cereda E, Valzolgher L, Pedrolli C. Mini nutritional assessment is a good predictor of functional status in institutionalised elderly at risk of malnutrition. *Clin Nutr* 2008; 27: 700-705.
26. Cereda E, Pusani C, Limonta D, Vanotti A. The ability of the Geriatric Nutritional Risk Index to assess the nutritional status and predict the outcome of home-care resident elderly: a comparison with the Mini Nutritional Assessment. *Br J Nutr* 2009; 102: 563-570.
27. Mahoney, F.I., Barthel, D.W. Functional evaluation: The Barthel Index. *Md State Med J* 1965; 14: 61-65.
28. Sergi G, Coin A, Enzi G, Volpato S, Inelmen EM, Buttarello M et al. Role of visceral proteins in detecting malnutrition in the elderly. *Eur J Clin Nutr* 2006; 60: 203-209.
29. Drescher T, Singler K, Ulrich A, Koller M, Keller U, Christ-Crain M et al. Comparison of two malnutrition risk screening methods (MNA and NRS 2002) and their association with markers of protein malnutrition in geriatric hospitalized patients. *Eur J Clin Nutr* 2010; 64: 887-893.
30. Vellas B, Guigoz Y, Baumgartner M, Garry P, Lauque S, Albarede JL. Relationship between nutritional markers and the mini nutritional assessment in 155 older persons. *J Am Geriatr Soc* 2000; 48: 1300-1309.
31. Calderón Reyes ME, Ibarra Ramírez F, García J, Gómez Alonso C, Rodríguez-Orozco AR. Compared nutritional assessment for older adults at family medicine settings. *Nutr Hosp* 2010; 25 (4): 669-75.

32. Gómez Ramos MJ, González Valverde FM, Sánchez Alvarez C. Nutritional status of an hospitalised aged population. *Nutr Hosp* 2005; 20 (4): 286-92.

33. Kuzuya M, Izawa S, Enoki H, Okada K, Iguchi A. Is serum albumin a good marker for malnutrition in the physically impaired elderly? *Clin Nutr* 2007; 26: 84-90.

34. Covinsky KE, Covinsky MH, Palmer RM, Sehgal AR. Serum albumin concentration and clinical assessments of nutritional status in hospitalized older people: different sides of different coins? *J Am Geriatr Soc* 2002; 50: 631-637.

35. Omran M, Moley J. Assessment of protein energy malnutrition in older persons, part II: laboratory evaluation. *Nutr* 2000; 16: 131-140.

36. Baron M, Hudson M, Steele R; Canadian Scleroderma Research Group (CSRG). Is serum albumin a marker of malnutrition in chronic disease? The scleroderma paradigm. *J Am Coll Nutr* 2010; 29: 144-151.

37. Feldblum I, German L, Castel H, Harman-Boehm I, Shahar DR. Individualized nutritional intervention during and after hospitalization: the nutrition intervention study clinical trial. *J Am Geriatr Soc* 2011; 59: 10-17.

38. Kagansky N, Berner Y, Koren-Morag N, Perelman L, Knobler H, Levy S. Poor nutritional habits are predictors of poor outcome in very old hospitalized patients. *Am J Clin Nutr* 2005; 82: 784-791.

39. Finucane P, Rudra T, Hsu R, Tomlinson K, Hutton RD, Pathy MS. Markers of the nutritional status in acutely ill elderly patients. *Gerontology* 1988; 34: 304-310.

40. Cuervo M, Ansorena D, García A, González Martínez MA, Astiasarán I, Martínez JA. Assessment of calf circumference as an indicator of the risk for hyponutrition in the elderly. *Nutr Hosp* 2009; 24 (1): 63-7.

41. Tsai AC, Chang TL. The effectiveness of BMI, calf circumference and mid arm circumference in predicting subsequent mortality risk in elderly Taiwanese. *Br J Nutr* 2011; 105: 275-281.

42. Izaola O, Luis Roman DA, Cabezas G, Rojo S, Cuéllar L, Terroba MC et al. Mini nutritional assessment (MNA) test as a tool of nutritional evaluation in hospitalized patients. *An Med Interna (Madrid)* 2005; 22: 313-316.

43. Cereda E, Vanotti A. The new Geriatric Nutritional Risk Index is a good predictor of muscle dysfunction in institutionalized older patients. *Clin Nutr* 2007; 26: 78-83.

44. De La Montana J, Miguez M. Suitability of the short-form mini nutritional assessment in free-living elderly people in the north-west of Spain. *J Nutr Health Aging* 2011; 15: 187-191.

45. Lee CG, Boyko EJ, Nielson CM, Stefanick ML, Bauer DC, Hoffman AR et al; Osteoporotic Fractures in Men Study Group. Mortality risk in older men associated with changes in weight, lean mass, and fat mass. *J Am Geriatr Soc* 2011; 59: 233-240.

46. Rolland Y, Lauwers-Cances V, Cournot M, Nourhashémi F, Reynish W, Rivière D, Vellas B, Grandjean H. Sarcopenia, calf circumference, and physical function of elderly women: a cross-sectional study. *J Am Geriatr Soc* 2003; 51: 1120-1124.

47. Jiménez Sanz M, Sola Villafranca JM, Pérez Ruiz C, Turienzo Llata MJ, Larrañaga Lavin G, Mancebo Santamaría MA, Study of the nutritional status of elders in Cantabria. *Nutr Hosp* 2011; 26 (2): 345-54.

48. Donini LM, De Felice MR, Tagliaccica A, De Bernardini L, Cannella C. Nutritional status and evolution of pressure sores in geriatric patients. *J Nutr Health Aging* 2005; 9: 446-454.

49. Thomas DR. Prevention and treatment of pressure ulcers. *J Am Med Dir Assoc* 2006; 7: 46-59.

50. Raffoul W, Far MS, Cayeux MC, Berger MM. Nutritional status and food intake in nine patients with chronic low-limb ulcers and pressure ulcers: importance of oral supplements. *Nutrition* 2006; 22: 82-88.

51. Langkamp-Henken B, Hudgens J, Stechmiller JK, Herrlinger-Garcia KA. Mini nutritional assessment and screening scores are associated with nutritional indicators in elderly people with pressure ulcers. *J Am Diet Assoc* 2005; 105: 1590-1596.

52. Hengstermann S, Fischer A, Steinhagen-Thiessen E, Schulz RJ. Nutrition status and pressure ulcer: what we need for nutrition screening. *JPEN J Parenter Enteral Nutr* 2007; 31: 288-294.