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CONUT: A tool for Controlling Nutritional Status. First validation in a hospital population

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Abstract

Background: **The serious problem of hospital undernutrition is still being underestimated, despite its impact on clinical evolution and costs. The screening methods developed so far are not useful for daily clinical practice due to their low effectiveness/cost ratio.**

Objective: **We present an screening tool for CONtrolling NUTritional status (CONUT) that allows an automatic daily assessment of nutritional status of all inpatients that undergo routine analysis.**

Design: **The system is based on a computer application that compiles daily all useful patient information available in hospital databases, through the internal network. It automatically assesses the nutritional status taking into account laboratory information including serum albumin, total cholesterol level and total lymphocyte count. We have studied the association between the results of the Subjective Global Assessment (SGA) and Full Nutritional Assessment (FNA) with those from CONUT, in a sample of 53 individuals.**

Results: **The agreement degree between CONUT and FNA as measured by kappa index is 0.669 (p = 0.003), and between CONUT and SGA is 0.488 (p = 0.034). Considering FNA as "gold standard" we obtain a sensitivity of 92.3 and a specificity of 85.0.**

Conclusions: **CONUT seems to be an efficient tool for early detection and continuous control of hospital undernutrition, with the suitable characteristics for these screening functions.**

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Key words: *Undernutrition, malnourishment, screening, nutritional assessment, albumin, total cholesterol, total lymphocyte count, clinical nutrition.*

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CONUT: UNA HERRAMIENTA PARA CONTROLAR EL ESTADO NUTRITIVO. PRIMERA VALIDACIÓN EN UNA POBLACIÓN HOSPITALARIA

Resumen

Antecedentes: **El grave problema de la desnutrición hospitalaria sigue siendo infravalorado, pese a sus repercusiones sobre la evolución clínica y los costes de la hospitalización. Los procedimientos de filtro desarrollados hasta ahora no son útiles para la práctica diaria por su baja relación efectividad/costo.**

Objetivo: **Presentamos un sistema de cribado para el CONtrol NUTricional que permite valorar a diario, de manera automática, la situación nutricional de la totalidad de los pacientes ingresados a los que se practica análisis de rutina.**

Diseño: **El sistema se basa en una aplicación informática que recopila a diario, a través de la red interna, aquellos datos de los pacientes ingresados que se consideran útiles para evaluar su estado nutricional y que están disponibles en bases de datos del hospital. Automáticamente determina la situación nutricional de los pacientes considerando los datos de laboratorio: albúmina, colesterol y linfocitos totales. Hemos estudiado la asociación entre los resultados del Subjective Global Assessment (SGA) y del Full Nutritional Assessment (FNA) con aquellos del CONUT, en una muestra de 53 individuos.**

Resultados: **El grado de concordancia entre el CONUT y el FNA, medido por el índice kappa es de 0,699 (p = 0,003), y entre el CONUT y el SGA es de 0,488 (p = 0,034). Si consideramos que el FNA es la "prueba de referencia", obtenemos una sensibilidad del 92,3 y una especificidad del 85,0.**

Conclusiones: **Parece que CONUT es una herramienta eficaz para la detección precoz y el control continuo de la desnutrición hospitalaria, con las características adecuadas a las funciones de cribado.**

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Palabras clave: *Desnutrición, malnutrición, cribado, valoración nutritiva, albúmina, colesterol total, recuento linfocitario total, nutrición clínica.*

Introduction

Undernutrition is a problem of great importance in clinical circles, despite the fact that it is still not highly considered by specialists and those responsible for Public Health. There are many studies showing that undernutrition prevalence in hospitalised patients ranges between 30-70%[1-5], varying according to definition of undernutition, used methodology and the specific group of studied patients.

The multiple consequences of undernutrition on immunological system[6-7], gastrointestinal tract[8], endocrine system, cardio-respiratory function[9], and on healing processes[10-11] are very well known. This is associated to an increase of morbidity-mortality rates, post-operative complications and an extension of length of stay (LOS) causing an increase in hospital assistance costs, up to an average of 60%[12-16].

The average prevalence of hospital severe malnutrition is around 10% in the literature[17]. Our the Nutritional Unit is only consulted in 3.12% of all inpatients[18], which means malnourished population in our hospital may be underdiagnosed.

The total assistance quality could be considerably improved by the arrangement of an automatic early detection system of undernutrition for all the inpatients. This method would allow to monitor the incidence of new cases, their follow-up and it would be followed by a full nutritional assessment and a intervention plan in order to counteract the effects of malnourishment, with the accompanying clinical and economic benefits.

Regarding this point, we fully agree with the conclusions of the 2003 Resolution of the Council of Europe on Food and Nutritional Care in Hospitals[19]. Which encourages European Countries to develop screening methods for assessing nutritional status and nutritional risk. The experts collect data from nutritional care providers and their practices of nutritional care and support showing it is sparse and inconsistent, and that the responsibilities in these context are unclear[20].

There are many studies that have tried to develop screening tools for early detection of undernutrition[21-27] but none of them can be applied on every inpatient, because among their evaluation parameters are some that require the intervention of an expert (physicians, nurses, and/or dieticians) for each patient individually, either for the anamnesis, for the physical examination or for the interpretation of laboratory analysis, which is not currently available in most of the hospitals around the world.

A screening tool should be clearly different from a full nutritional assessment, and should be based on easy and cheap-to-obtain measures and procedures, because these must be put into effect with as many patients as possible, to identify those who need a further complete nutritional evaluation, and possible treatment. We also consider it essential that nutritional control can be repeated throughout the hospitalisation, in order to be able to check the evolution of those patients previously detected as well as recognise new patients already hospitalised.

We have developed a tool that allows us to put into practice a permanent screening system, feasible for nearly all inpatients, automatically, without raising costs and depending initially only on historical information from different data bases, produced routinely from the current computer technology infrastructure available in most of our hospitals.

In this paper we describe what our screening tool consists of, and we study the agreement degree between this new procedure and two other classical nutritional evaluation methods: the Subjective Global Assessment (SGA)[25-26] and the Full Nutritional Assessment (FNA).

Subjects and methods

Description of the Screening Tool for the Nutritional Control (CONUT)

The application has been developed in the Nutritional Section and in the Clinical Epidemiology Unit of our Hospital Universitario de la Princesa (HUP), using Microsoft Visual Foxpro 6.0 as database manager. Our hospital, linked to Universidad Autonoma of Madrid, is a 500 beds hospital, only for adults, and services a population area of 450,000.

The screening tool for "CONtrolling NUTritional status" (from now on, CONUT) is based on a computer application that makes a daily data compilation from different sources in the hospital, through an internal network. The posterior processing of all this information permits the selection and identification of patients with different levels of undernutrition (stage 1) or with a possible nutritional risk (stage 2) (fig. 1).

The collection of daily information is possible, on one hand, thanks to the interconnection of computers in hospital through de fibre optic corporate local network, and on the other hand, to the existence of each patient's history case number (HCN), and its universal use in all databases of the hospital as a patient identifying tool.

The information sources are the databases generated in the Admission Service, in the Central Laboratory and in the Nutritional Unit.

The Admission Service also has several databases, that provides information, which allows us to identify and locate the patient in the hospital (HCN, age and sex, department, bed number, physician in charge), and admission data (date, diagnosis presumption, readmissions).

The Central Laboratory of the hospital also has an information system where all the results of the analyses performed at the hospital (in and outpatients), and from Primary Health Care are registered. The system provides automatically the same administration data (HCN, patient's location, requesting doctor) and also

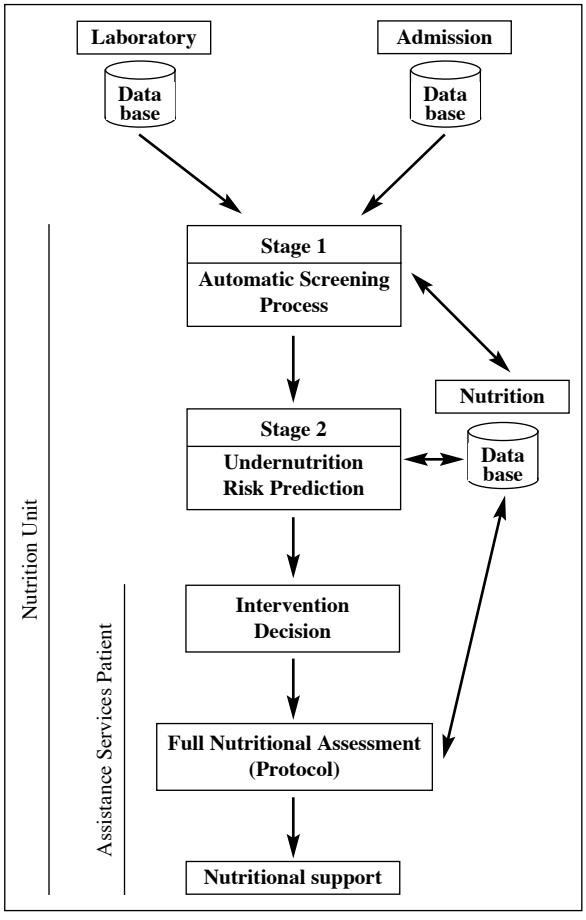

Fig. 1.—Process for the early detection of undernutrition in hospitals.

the analysis date. Among all the accumulated routine analysis data, we select those most frequently used, which are also helpful in the evaluation of nutritional status: serum albumin, total cholesterol level and total lymphocyte count. Haematocrit value is used only as an indicator of the concentration variations, caused by a change in plasma volume.

The result of processing all this information for the user is a screen where all the data coming from different sources are integrated.

Classification of patients according to their nutritional status and nutritional risk

The screening process has two different steps:

1. The first step is the nutritional status assessment. It is done automatically by the tool using two biochemical parameters (serum albumin and cholesterol level) and one immune indicator (total lymphocyte count). Serum albumin is used as an indicator of protein reserves[28-29]. The measurement is taken with a Hitachi -747 analyser, BCG technique (Bromocresol method). Cholesterol is used as a caloric depletion parameter[30-31]. It is measured with a Hitachi -747 analyser, CHOD-PAB method. Finally, total lymphocyte count is used as an indicator of loose of immune defences caused by undernutrition[32-34]. It is measured with an SE-9000 analyser (conventional method). The levels for these three parameters, as well as the scores assigned by the screening tool, according to the undernutrition degree, are shown in table I. Scores have been placed by the authors, according to the information published and the heuristic knowledge obtained from long experience. The albumin has double the rating than cholesterol and lymphocytes, as it provides more "weight" as an undernutrition indicator. Anyway, the relative weight of these scores will be probably adjusted in the future, by means of stepwise multivariate analysis. Following this rating, the application classifies patients in four groups of nutritional status: normal, slight undernutrition, moderate undernutrition and severe undernutrition. In this study we have selected an adult population so we still don't know if CONUT can be applied to infants or elderly until new studies validate the tool in those group of ages.

Table I
Assessment of undernutrition degree by CONUT

	Undernutrition Degree			
Parameter	*Normal*	*Light*	*Moderate*	*Severe*
Serum Albumin (g/dl)	3.5 - 4.5	3.0 - 3.49	2.5 - 2.9	< 2.5
Score	**0**	**2**	**4**	**6**
Total Lymphocytes/ml	> 1600	1200-1599	800-1199	< 800
Score	**0**	**1**	**2**	**3**
Cholesterol (mg/dl)	> 180	140-180	100-139	< 100
Score	**0**	**1**	**2**	**3**
Screening Total Score	**0 - 1**	**2 - 4**	**5 - 8**	**9 - 12**

2. The second step is the nutritional risk assessment. It is made by a trained physician who uses the scores given automatically by the tool plus the other information available in the screen: patient's biochemical evolution (since the admission date, or even from earlier analyses, either from the outpatient departments, or from previous admissions), the diagnosis at admission, the patient's age, and the length of stay. With this data the physician establishes the risk of undernutrition, even if the patient is not yet malnourished, since it is possible to identify patients with no undernutrition in the present, but with a nutritional risk of developing it in a short-medium timeframe due to the diagnosis and/or the therapeutical procedure.

The following step would be the intervention stage. The Nutrition Section contacts with the department in charge of the moderate to severe malnourished patients (obtained from the first step of CONUT), and also of those theoretically at risk (second phase), and performs a full nutritional assessment. If necessary, nutritional support is initiated and the patient is weekly re-evaluated either by CONUT and also by the Nutrition Team.

Validation Study of the Screening Tool

To know the validity of CONUT we have studied the association and the degree of agreement among the obtained diagnosis with the first step of this tool and the one obtained with two different methods commonly used for assessing the nutritional status. Such methods were the Subjective Global Assessment and the Full Nutritional Assessment, as defined in our the Nutritional Protocol.

Subjective Global Assessment (SGA): Described by Detsky and cols.[25-26], is a clinical technique, which assesses nutritional status based on features of the history and physical examination. The history records data basically based on anamnesis, where all data related to weight changes in the last 6 months, modifications in diet intakes, presence of gastrointestinal symptoms and functional capacity. The physical examination includes: presence of loss of subcutaneous fat, muscle wasting ankle edema, sacral edema and ascites. The result obtained classifies patients in: normal or well nourished, moderately (or suspected of being) undernourished and severely malnourished.

Full Nutritional Assessment (FNA): This is a nutritional evaluation procedure adopted by the Nutrition Protocol of our hospital, based on the recommendations of the Spanish Society of Parenteral and Enteral Nutrition (SENPE)[35]. It includes: patient's history and actual diagnosis, therapeutic procedures, physical examinations (weight, height and BMI, plicometry for tricipital, bicipital, subscapular and suprailiac skinfold[36], and bioimpedance. The lipocaliber used is Holtain, and the Impedianciometer is a Body Fat Analyzer Maltron (monofrequency). Laboratory data is also recorded including serum determinations of albumin, total cholesterol level, total lymphocyte count, haemogram, pre-albumin, transferrin, iron, lipids profile, serum and urine ions (Na, K, Cl), hepatic, renal and endocrine-metabolic function, 24 hour-clearance of creatinine and nitrogen.

The study was doubled blinded. All the patients of the study had SGA and FNA. Two different teams made the evaluations: SGA was made by two interns, after being trained for the project, not knowing the results obtained from the FNA and the screening with CONUT. FNA was made by the Nutrition Section physicians, helped by the Nutrition nurses, who made the anthropometrics and bioimpedance, not knowing the results of the SGA and the screening with CONUT. As a result of such an evaluations, the patients wereare classified in four groups: normal nourished patients, slightly, moderate or severely undernourished patients.

Validation and balancing of parametersfactors used in the screening tool

For this initial study concerning the validity of the screening tool, we selected a sample of 53 patients out of a the total of 229 patients admitted at Hospital Universitario de la Princesa during four consecutive Mondays, after excluding the Intensive Care Unit, Oncology-Haematology patients under chemo or radiotherapy and patients that had been under major surgery in the last fifteen days. The reason for excluding these patients was the impact of their disease or therapeutical procedure on their biochemical and immune parameters, which could introduce biasing in the initial validation of the screening tool that we present in this study[37]. In the same way, patients with dementia or low consciousness levels, who were impossible to test for the nutritional evaluation using control methods (SGA and FNA), were also excluded.

During the following four days after admission, an assessment of the nutritional status of patients (using SGA, and FNA and CONUT) was made to those patients who fulfilled inclusion criteria.

Statistical analysis: The study of the differences in the means of the screening parameters (serum albumin, total cholesterol and lymphocytes count) between the different degrees of undernutrition diagnosed following SGA and FNA, was made using a variance analysis. The association between the results of the SGA and FNA with those from the screening tool, CONUT, was studied using the X^2 test. Afterwards, the origin of the significance was analysed, using Freeman's[38] method calculating the kappa indexes[39], as a measurement of the agreement degree and of the corresponding significance tests.

In the same way, we studied the sensitivity and specificity of the screening tool, using FNA as the "gold

Table II
Sample description

Nº of patients	53
Age (years), mean ± SD	66.8 ± 16.58
Males/females, nº (%)	28 (52) / 25 (47)
Height (cm.), mean ± SD	163.62 ± 8.14
Weight (kg.), mean ± SD	68.7 ± 12.9
BMI, mean ± SD	25.6 ± 4.85
BMI, nº (%):	
• < 20	8 (15)
• 20 – 25	18 (34)
• > 25	27 (51)

standard". In all cases we considered significant all p values under 0.05.

The analyses were done using SPSS v.8.0 and EPIDAT v.2.0.

Results

All data referring to age, sex, weight and BMI of patients studied are described in table II. The mean age of the study population was 66.8, with a similar proportion of men (52.8%) and women (47.2%). The mean BMI was 25.6 ± 4.85, being more than half of our population study overweight (BMI > 25). Inpatients percentage distribution was the following: Cardiology 7.5%, Cardiovascular Surgery 7.6%, General and Digestive Surgery 17%, Maxilophacial Surgery 1.9%, Thoracic Surgery 5.7%, Gastroenterology 18.9%, Internal Medicine 15.1%, Nephrology 3.8%, Neumology 5.7%, Neurology 1.9%, Otorinolaryngology 3.8%, Reumathology 1.9%, Orthopedics 5.7% and Urology 3.8%.

The prevalence of moderate-severe undernutrition varied from 24.6% in the FNA to 43% in SGA as shown in table III.

No correlation between BMI and undernutrition degree evaluated by any of the three methods in our study population was found (table IV).

Table III
Degrees of undernutrition as evaluated by CONUT, SGA and FNA

	Number of cases (Percentage)		
Undernutrition degree	*CONUT*	*SGA*	*FNA*
Normal	9 (17)	30 (56.6)	26 (49.1)
Light undernutrition	28 (52.8)	–	14 (26.4)
Moderate undernutrition	13 (24.5)	19 (35.5)	10 (18.9)
Severe undernutrition	3 (5.7)	4 (7.5)	3 (5.7)

Table IV
Relationship between BMI and undernutrition degree as evaluated by CONUT, SGA and FNA

	Mean BMI (kg/m2) ± S.D		
	CONUT	*SGA*	*FNA*
Normal	29.9 ± 5.0	26.3 ± 4.6	26.0 ± 4.9
Light	25.8 ± 4.7	–	26.3 ± 4.0
Moderate	23.8 ± 7.5	24.9 ± 4.5	23.1 ± 4.7
Severe	27.9 ± 7.8	24.3 ± 8.2	27.7 ± 8.2
p value	0.381	0.515	0.313

Subjective Global Assessment differentiates three levels of nutritional status and Full Nutritional Assessment four. We collapsed the normal and light undernutrition in FNA in order to compare the results of the relationship between the three parameters and the degrees of malnutrition assessed by SGA and FNA, founding a linear trend so the higher the undernutrition is, the lower the albumin/cholesterol levels and the lymphocyte count are. This trend reached statistically significance in the three parameters for FNA and in albumin levels for SGA. Cholesterol levels and lymphocyte count were close to significance for SGA (p = 0.131 and p = 0.120 respectively) (figs. 2, 3 and 4).

Tables V and VI show the results of the raw relationship between CONUT and SGA and between CONUT and FNA, as well as their corresponding hypothesis tests, finding a high significance in both cases. We also show the analysis after the collapse of tables in two undernutrition degrees (normal-slightly undernourished and moderate-severe undernourished) with their corresponding hypothesis test and agreement degree measures, obtaining statistically significant results (p = 0.034 and kappa index = 0.488 for SGA, p = 0.003 and kappa index = 0.669 for FNA (tables V bis and VI bis).

Taking FNA as the gold standard for assessing nutritional status, the sensitivity of the screening tool was 92.30% and the specificity was 85%.

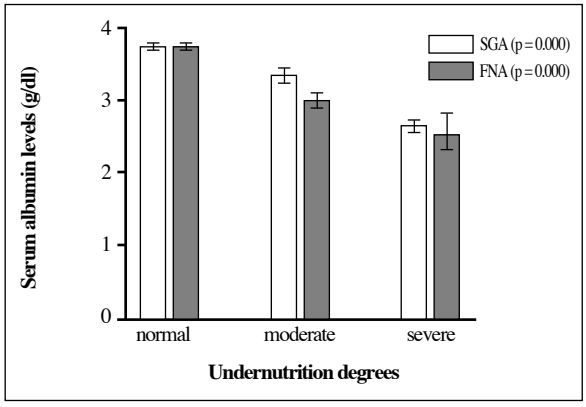

Fig. 2.—Serum albumin and undernutrition degrees assessed by SGA and FNA.

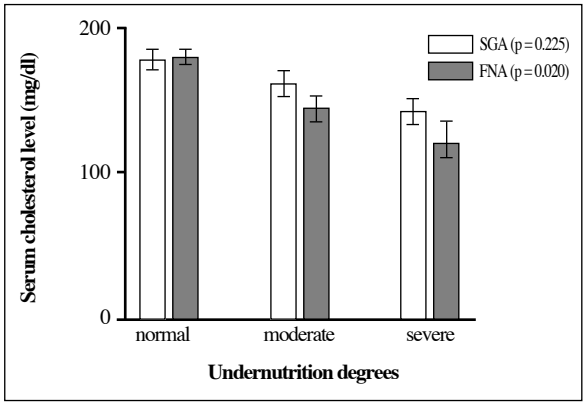

Fig. 3.—Serum cholesterol and undernutrition degrees assessed by SGA and FNA.

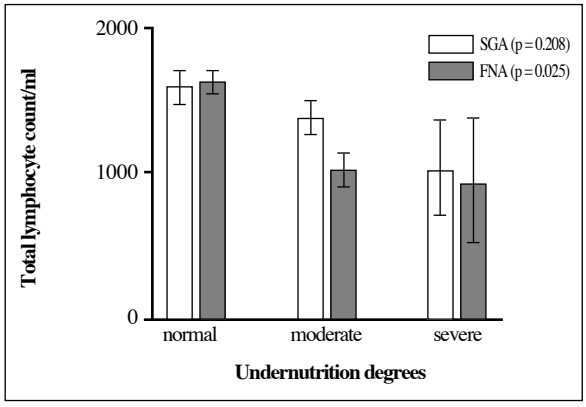

Fig. 4.—Total lymphocyte count and undernutrition degrees assessed by SGA and FNA.

Discussion

In this preliminary study, the screening tool for detecting patients malnourished (CONUT) appears to be useful in a group of patients whose parameters are not significantly affected by the severity of the illness or by very aggressive therapeutic procedures[37].

The prevalence of moderate or severe malnutrition found by SGA is higher than those found by FNA and CONUT because the former only differentiates three categories instead of four, so some patients classified as moderate undernourished by SGA are considerated normal or slightly malnourished by the other two methods.

No relationship was found between Body Mass Index (BMI) and undernutrition in our study population, assessed by any of the three methods used. BMI could be a good indicator of medium/long term undernutrition in general population, but it does not seem to be so indicative in a hospital environment (see table IV) where acute undernutrition may not be reflected by weight loss and a decrease in BMI.

We have found a significant statistical association between the evaluation of undernutrition with CONUT and the results obtained from SGA and FNA (tables V and VI), and this association does not disappear after collapsing the tables (tables V bis and VI bis). This would support the tool utility for differentiating patients that would require immediate nutritional assistance (moderate to severe malnutrition) from those that would be included in prevention programs (normal to slightly malnourished patients).

Agreement levels between CONUT and SGA and FNA (k = 0.488, k = 0,669, respectively) are very acceptable in routine clinical examination[40], being higher with FNA as this method includes not only retrospective nutritional data (as SGA does) but also objective parameters (anthropometry and blood tests), more in accordance with CONUT, based only on objective data.

The high sensitivity (92,30%) and specificity (85%) of the tool, compared to the Full Nutritional Assessment, as our "gold standard", confirm CONUT as a valid screening method for early detection of hospital malnutrition.

The first step of CONUT as a nutritional status screening seems to have many advantages when compared to SGA or Full Nutritional Asssessment. It is easy to use and simple to understand, it includes both the nutritional status and the disease and/or therapeutic procedures during the inpatient stay. As it is quicker and less costly, CONUT allows the Nutritional

Table V
Relationship between undernutrition degrees evaluated by SGA and CONUT

	Number of patients			
	SGA			
CONUT	*Normal*	*Moderate*	*Severe*	*TOTAL*
Normal	14	4	0	18
Light	12	5	0	17
Moderate	4	8	3	15
Severe	0	2	1	3
TOTAL	30	19	4	53

X^2 = 17.656, **p value = 0.007**.

Table V bis
Relationship between undernutrition degrees evaluated by SGA and CONUT after collapsing the tables

	Number of patients		
	SGA		
CONUT	*Normal*	*Moderate-Severe*	*TOTAL*
Normal-Light	26	9	35
Moderate-Severe	4	14	18
TOTAL	30	23	53

X^2 = 13.57, **p value = 0.034**. Kappa index: 0.488 (IC 95% 0.252 - 0.723).

Table VI
Relationship between undernutrition degrees evaluated by FNA and CONUT

	Number of patients				
			SGA		
CONUT	*Normal*	*Light*	*Moderate*	*Severe*	*TOTAL*
Normal	15	3	0	0	18
Light	10	6	1	0	17
Moderate	1	5	8	1	15
Severe	0	0	1	2	3
TOTAL	26	14	10	3	53

$X^2 = 50.25$, **p value < 0.001**.

Table VI bis
Relationship between undernutrition degrees evaluated by FNA and CONUT after collapsing the tables

	Number of patients		
		SGA	
CONUT	*Normal*	*Moderate-Severe*	*TOTAL*
Normal-Light	34	1	35
Moderate-Severe	6	12	18
TOTAL	40	13	53

$X^2 = 24.65$, **p value = 0.003**. Kappa Index: 0.669 (IC 95% 0.448 - 0.889). Sensitivity: 92.30 (IC 95% 62.08 - 99.59). Specificity: 85.00 (IC 95% 69.47 - 93.75).

Unit to follow up on all the inpatients daily or weekly, and also follow their evolution at Primary Health Care visits. These advantages fulfil the 2003 Resolution of the European Council on Food and Nutritional Care in Hospitals[20].

The present study includes just a small number of patients, with no severe diseases or therapeutic procedures. We are now embarking on a larger study with all kind of patients (excluding infants), diseases and treatments in order to assess the viability of our tool in screening for nutritional status and risk (second step of the tool).

Obviously, the biochemical parameters CONUT uses are affected by the disease or the procedure itself. The European Council states in its first paragraph that "Nutritional risk should take into account nutritional status and the severity of the disease", as it is impossible to separate both situations. The tool we describe here does not aim to differentiate one from the other. CONUT screens for patients already malnourished and for patients at risk of malnutrition (itself or related to the disease and/or treatment). We have found a linear trend between levels of serum albumin, cholesterol and lymphocyte count and the degree of malnutrition obtained by SGA and FNA, and these degrees of undernutrition perfectly correlate with those of CONUT. It confirms that biochemical parameters used in CONUT are not only indices of disease severity but also of nutrition markers.

Larger studies will help us to validate the screening tool in all patients and situations. If so, CONUT could be a good method to be used in hospitals and Primary Health Care centres.

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