Nutrición Hospitalaria

Nutr Hosp. 2011;26(3):480-487
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Original

Agreement and association between the phase angle and parameters of nutritional status assessment in surgical patients

L. Scheunemann[1], E. Wazlawik[1], J. L. Bastos[2], T. Ristow Cardinal[1] and L. Mayumi Nakazora[1]

[1]*Post-Graduate Program in Nutrition. Federal University of Santa Catarina. Florianópolis. SC. Brazil.* [2]*Department of Public Health of Federal University of Santa Catarina. Florianópolis. SC. Brazil.*

Abstract

Background & aims: **To assess the agreement and the association between phase angle (PA) and parameters of nutritional status in surgical patients.**

Methods: **This was a cross-sectional study that involved 98 patients admitted for elective gastrointestinal or hernia repair surgery. The risk and nutritional status were evaluated through Nutritional Risk Screening 2002 (NRS 2002), Subjective Global Assessment (SGA), Body Mass Index (BMI) and Total Lymphocytes Count (TLC). These assessments were compared with the mean standardized PA (SPA), obtained by Bioelectrical Impedance Analysis (BIA). Statistical analysis included kappa coefficient, Student's *t*-test, Mann-Whitney test, and the construction of a ROC Curve.**

Results: **The highest kappa agreement was obtained between the SPA and the SGA (0.27; CI95% 0.06-0.48). Malnourished patients diagnosed by NRS 2002, SGA and TLC had a significantly lower mean SPA as compared to those who were well-nourished. A cut-off point of 0.8 for SPA showed 82.6% (CI95% 65.0-100.0%) sensitivity and 40.6% (CI95% 23.0-58.2%) specificity.**

Conclusion: **The SPA presented weak agreement with the methods of nutritional assessment, as well as low specificity, and could not be recommended as a marker of nutritional status, despite the fact that the lowest values for SPA were found in malnourished patients.**

(*Nutr Hosp.* 2011;26:480-487)

DOI:10.3305/nh.2011.26.3.4816

Key words: *Nutritional stattus assessment. Bioelectrical impedance analysis. Phase angle. Surgical patients.*

CONCORDANCIA Y ASOCIACIÓN ENTRE EL ÁNGULO DE FASE Y LOS PARÁMETROS DE EVALUACIÓN DEL ESTADO NUTRICIONAL EN PACIENTES QUIRÚRGICOS

Resumen

Introducción y objetivos: **Evaluar la concordancia y asociación entre el ángulo de fase (AF) y los parámetros del estado nutricional en pacientes quirúrgicos.**

Métodos: **Se desarrolló un estudio de sección transversal con 98 pacientes admitidos para una cirugía gastrointestinal o de hernia. Se evaluó el riesgo y el estado nutricional a través del Rastreo de Riesgo Nutricional 2002 (RRN 2002), la Valoración Global Subjetiva (VGS), el Índice de Masa Corporal (IMC) y el Recuento Total de Linfocitos (RTL). Estos métodos fueron comparados con la media del AF estandarizado (AFE) obtenido por medio del Análisis de Impedancia Bioeléctrica (AIB). Los Análisis estadísticos incluyeron el coeficiente *kappa*, el test *t* Student, el test de Mann-Whitney, y la construcción de la Curva ROC.**

Resultados: **La concordancia *kappa* más alta se obtuvo entre el AFE y el VGS (0,27; CI95% 0,06-0,48). Los pacientes desnutridos diagnosticados por el RRN 2002, VGS y el RTL, tuvieron una media estadística de AFE significativamente menor comparado con aquellos que estaban bien nutridos. Un punto de corte del 0.8 para un AFE mostró 82,6% (CI95% 65,0-100,0%) de sensibilidad y 40,6% (CI95% 23,0-58,2%) de especificidad.**

Conclusión: **El AFE presentó una concordancia débil con los métodos de evaluación nutricional, así como una baja especificidad y no pudo ser recomendado como un indicador del estado nutricional, a pesar de que los valores más bajos del AFE fueron encontrados en pacientes desnutridos.**

(*Nutr Hosp.* 2011;26:480-487)

DOI:10.3305/nh.2011.26.3.4816

Palabras clave: *Evaluación del estado nutricional. Análisis por impedancia bioeléctrica. Ángulo de fase. Pacientes quirúrgicos.*

Correspondence: Elisabeth Wazlawik.
Universidade Federal de Santa Catarina.
Campus Universitário. Trindade.
SCCP: 88040-970 Florianópolis. Brazil.
E-mail: wazlawik@ccs.ufsc.br

Recibido: 19-V-2010.
Aceptado: 21-VII-2010.

Abbreviations

BCM: Body Cell Mass.
BIA: Bioelectrical Impedance Analysis.
BMI: Body Mass Index.
NRS 2002: Nutritional Risk Screening 2002.
PA: Phase Angle.
R: Resistance.
ROC curve: Receiver Operating Characteristic Curve.
SGA: Subjective Global Assessment.
SGA A: Well-nourished according to Subjective Global Assessment.
SGA B: Suspected or moderate malnutrition according to Subjective Global Assessment.
SGA C: Severe malnutrition according to Subjective Global Assessment.
SPA: Standardized Phase Angle.
TLC: Total Lymphocytes Count.
UFSC: Federal University of Santa Catarina.
Xc: Reactance.

Introduction

Hospital malnutrition has become a concern and a challenge throughout the world,[1,2,3] since it has numerous negative consequences including increased morbidity and mortality, extended hospitalization, and, in addition, increased costs for the health care system.[3,4] Hospital malnutrition is related to both a higher frequency and higher severity of post-operative complications,[5] especially following surgery of the digestive tract.[6]

The application of a method to detect malnutrition has been made difficult by the absence of a universally accepted criterion for its identification.[5] At present, there is no gold-standard method to identify patients with malnutrition or at nutritional risk.[6]

Bioelectrical impedance analysis (BIA) is a sensitive, reliable, safe and inexpensive method[4-6] that is rarely used for the determination of nutritional status.[7] This method may overcome some limitations presented by other methods by incorporating both functional and morphological assessment.[6] BIA measures body component resistance (R) and reactance (Xc) by recording a voltage drop in applied current.[7] Resistance is related to the water content in the tissues, while reactance is the resistive effect produced by the tissue interfaces and cell membranes.[7,8]

The phase angle (PA), is calculated directly from R and Xc, so it reflects the relative contributions of fluid (R) and cell membranes (Xc).[7,9] This measure has a number of advantages, such as independence from regression equations,[10] and the fact that it can be calculated even in situations in which it is not possible to estimate the body composition.[7,8] Furthermore, it can be performed even in patients in whom the current weight and height cannot be measured.[6,11] Thus, interest in comparing the PA with other methods used in the nutritional assessment of hospitalized patients is clearly justified, in order to obtain evidence on its performance as an indicator of nutritional status.

The aim of this study was to evaluate the utility of standardized PA (SPA) in the determination of the nutritional status of surgical patients by investigating the agreement, as well as the association between SPA and nutritional status diagnosed by Nutritional Risk Screening 2002 (NRS 2002), Subjective Global Assessment (SGA), Body Mass Index (BMI) and Total Lymphocytes Count (TLC).

Materials and methods

Patients and procedure

This was a cross-sectional study, carried out between March and August 2007 with patients of both sexes, aged ≥ 18 years and admitted for elective gastrointestinal surgery or for hernia repair, hospitalized in Surgical Clinic 1 at the University Hospital of the Federal University of Santa Catarina (UFSC), Florianópolis, Santa Catarina, Brazil.

Patients who were admitted for bariatric surgery, those fitted with pacemakers, pregnant women, those who were breastfeeding or those presenting difficulty in engaging with the interviewer for data collection were excluded from the study. The following variables were assessed in all patients: sex, age, main diagnosis and associated diseases.

The study was approved by the Committee for Ethics in Research in Humans at UFSC and, prior to data collection, each participant signed a term of free and informed consent.

Nutritional assessment

Nutritional status was evaluated during the preoperative period by the same investigator, according to NRS 2002, SGA, BMI, TLC and SPA.

Nutritional Risk Screening 2002

The NRS 2002 was performed according to the recommendations set forth by Kondrup et al.[12] Nutritional risk was through two components: impaired nutritional status and disease severity. Nutritional status was determined from three variables: BMI, recent weight loss, and food intake during the week before admission, taking into account the worst indicator. The disease severity was analyzed as an indicator of metabolic stress and increased nutritional requirements. A score between 1 and 3 was given according to the recommendations for each component. Patients with a total score of three or more (when the age of the patient was ≥ 70 years, a value of one was added to the total score) were considered at nutritional risk.

Subjective Global Assessment

The SGA was carried out using the protocol developed by Detsky et al.[13] This relies on the patient's history regarding weight loss, dietary intake, gastrointestinal symptoms, functional capacity, and physical signs of malnutrition (loss of subcutaneous fat or muscle mass, oedema, ascites). Patients were classified as well nourished (A), moderately or suspected of being malnourished (B) or severely malnourished (C). For the purpose of statistical analysis, patients were grouped in well-nourished (SGA A) and malnourished (SGA B and C).

Body Mass Index

The BMI was calculated as: current weight (kg)/height^2 (m)[14] and classified according to World Health Organization.[14,15] Subjects were grouped in well-nourished (BMI ≥ 18.5 kg/m^2) and malnourished (BMI < 18.5 kg/m^2) patients.

Total Lymphocytes Count

The TLC was analyzed automatically by an ABX PENTRA 120 automated haematological analyser (Kyoto, Japan). The TLC value (units per mm^3) was obtained from the medical records of each patient, considering the cut-off points described by Blackburn & Thornton.[16] The patients were grouped in well-nourished (lymphocytes ≥ 1,200 mm^3) and malnourished (lymphocytes < 1,200 mm^3) for the purposes of statistical analysis.

Phase Angle

Tetrapolar BIA was performed using a calibrated Biodynamics portable apparatus, model 310e (Seattle, WA, USA), which applies a current of 800 μA at a single frequency of 50 kHz. The measurements were made early in the morning, with patients fasting for at least 4 h. BIA was conducted while patients were lying supine on a bed, with legs apart and arms not touching the torso. Those who were able to urinate were asked to do so before the measurements were carried out. The examination procedures, as well as control of other variables affecting the validity, reproducibility and precision of the measurements were carried out according to standards of the National Institutes of Health.[17] Resistance (R) and reactance (Xc) were directly measured in ohms, with a single assessment being made of each. The phase angle was calculated using the following equation: [arc tangent (Xc /R)] x (180/π).

Before employing the PA as a nutritional parameter, it was first standardized using the reference values for sex and age of a Swiss population,[18] since there are still no published data for the Brazilian population. The SPA was calculated from the equation: [(observed PA-mean PA for sex and age)/standard deviation of PA for sex and age], where a SPA < 0.8 was considered as an indicator of malnutrition.[6]

Statistical Analysis

Statistical analysis was performed using Stata, version 9.0 for Windows (Stata Corporation, College Station, TX, USA). Results are expressed as mean ± standard deviation. Association among the categorical variables was determined with Fisher's test. The agreement between SPA and NRS 2002, SGA, BMI and TLC in the diagnosis of malnutrition was investigated using the kappa coefficient, with the following criteria being applied in the interpretation of values: $k \leq 0.20$ (poor agreement); $0.21 \leq k \leq 0.40$ (weak agreement); $0.41 \leq k \leq 0.60$ (moderate agreement); $0.61 \leq k \leq 0.80$ (good agreement); $k > 0.80$ (very good agreement).[19]

Quantitative variables with normal distributions were analyzed with Student's *t* test and non-parametric variables were analyzed with the Mann-Whitney test to compare SPA values according to the categories of NRS 2002, SGA, BMI and TLC. A level of significance of $p < 0.05$ was used.

The sensitivity and specificity of cut-off points for the PA were analyzed by constructing a ROC (Receiver Operator Characteristic) curve, considering the SGA as the reference method.

Results

During the data collection period, 98 of 416 patients admitted to the clinic were enrolled in the study, following the pre-specified eligibility criteria. The main reason for the exclusions was the high number of patients admitted for surgical procedures other than those included in this study (gastrointestinal or hernia repair).

These 98 patients were aged between 20 and 85 years (46.3 ± 13.6 yr). Men had a higher mean age (49.3 ± 13.5 yr) than women (44.8 ± 13.5 yr). Table I presents the general characteristics of the patients. Women comprised 67.3% of the sample, and the majority of the sample consisted of adults (84.7%). According to the main diagnosis, women predominantly presented benign diseases of the pancreas or biliary tract (74.2%), while amongst men the most common conditions were gastrointestinal cancer (25%) and abdominal hernia (31.3%). Two-thirds of all patients did not present any associated disease.

Table II shows the nutritional risk and the nutritional status of the patients, according to NRS 2002, SGA, BMI, TCL and SPA. The prevalence of nutritional risk and malnutrition in the whole sample varied markedly according to the method used, as follows: 27.5% (NRS 2002), 29.6% (SGA), 4.1% (BMI), 11.5% (TLC) and

Table I
Socio-demographic and clinical characteristics of the patients, by sex (n = 98)

Variable	*N (%)*	*Men*		*Women*		*p-value*[a]
		N	*(%)*	*N*	*(%)*	
N patients	98 (100.0)	32	(32.7)	66	(67.3)	< 0.001
Age (years)						0.6
< 60	83 (84.7)	26	(81.3)	57	(86.4)	
≥ 60	15 (15.3)	6	(18.8)	9	(13.6)	
Main diagnosis						< 0.001
Gastrointestinal cancer	14 (14.3)	8	(25.0)	6	(9.1)	
Benign disease of the pancreas or biliary tract	60 (61.2)	11	(34.4)	49	(74.2)	
Benign disease of the oesophagus	10 (10.2)	3	(9.4)	7	(10.6)	
Abdominal hernia	14 (14.3)	10	(31.3)	4	(6.1)	
Associated diseases						1.0
No	65 (66.3)	21	(65.6)	44	(66.7)	
Yes	33 (33.7)	11	(34.4)	22	(33.3)	

[a]Fisher's exact test for association with sex.

23.5% (SPA). There was no difference by sex in the prevalence of malnutrition based on these methods. According to SGA, 18.4% of the patients presented moderate malnutrition or suspected malnutrition and 11.2% severe malnutrition. With regard to BMI, 3.1% of the patients exhibited mild thinness (BMI 17.0-18.49 kg/m^2) and 1.0% moderate thinness (BMI 16.0-16.99 kg/m^2). In relation to TLC, 7.7% presented moderate malnutrition and 3.9% severe malnutrition. It should be noted that TLC values were unavailable for 20 patients, so this parameter was analyzed in 78 individuals only.

Table II
Nutritional status of the patients according to Nutritional Risk Screening (NRS 2002), Subjective Global Assessment (SGA), Body Mass Index (BMI), Total Lymphocytes Count (TLC) and standardized phase angle (SPA), according to sex (n = 98)

Variable	*N (%)*	*Men*		*Women*		*p-value*[a]
		N	*(%)*	*N*	*(%)*	
NRS 2002						0.3
< 3	71 (72.5)	21	(65.6)	50	(75.8)	
≥ 3	27 (27.5)	11	(34.4)	16	(24.2)	
SGA						0.8
A	69 (70.4)	22	(68.8)	47	(71.2)	
B + C	29 (29.6)	10	(31.3)	19	(28.8)	
BMI (kg/m^2)						0.3
≥ 25	53 (54.1)	14	(43.8)	39	(59.1)	
18.5-24.99	41 (41.8)	16	(50.0)	25	(37.9)	
< 18.5	4 (4.1)	2	(6.3)	2	(3.0)	
TLC[b] *(mm^3)*						1.0
≥ 1,200	69 (88.5)	24	(88.9)	45	(88.2)	
< 1,200	9 (11.5)	3	(11.1)	6	(11.8)	
SPA						0.8
≥ 0.8	75 (76.5)	24	(75.0)	51	(77.3)	
< 0.8	23 (23.5)	8	(25.0)	15	(22.7)	

NRS 2002, Nutritional Risk Screening 2002: NRS 2002 < 3 normal nutrition; NRS 2002 ≥ 3: nutritional risk; SGA, Subjective Global Assessment: SGA A: normal nutrition; SGA B + C malnutrition; BMI, Body Mass Index: BMI ≥ 18 kg/m^2: normal nutrition; BMI < 18.5 kg/m^2 malnutrition; TLC; Total Lymphocytes Count TLC ≥ 1,200 mm^3: normal nutrition; TLC < 1,200 mm^3: malnutrition; SPA, Standardized Phase Angle: SPA ≥ 0.8: normal nutrition and SPA < 0.8 malnutrition.
[a]Fisher's exact test for association with sex.
[b]There were 20 values ignored for this variable.

Table III
Agreement between the standardized phase angle (SPA) and Nutritional Risk Screening (NRS 2002), Subjective Global Assessment (SGA), Body Mass Index (BMI) and Total Lymphocytes Count (TLC), in diagnosing malnutrition, according to sex (n = 98)

Definition criteria for malnutrition	*Kappa coefficient (CI[a])*		
	Total	*Men*	*Women*
NRS 2002 ≥ 3	0.25 (0.04-0.46)	0.33 (-0.01-0.68)	0.20 (-0.06-0.046)
SGA B + C	0.27 (0.06-0.48)	0.39 (0.04-0.73)	0.21 (-0.04-0.47)
BMI < 18.5 kg/m^2	0.01 (-0.13-0.14)	0.11 (-0.21-0.43)	-0.06 (-0.13-0.02)
TLC < 1,200 mm^3[b]	0.22 (-0.02-0.46)	0.29 (-0.11-0.69)	0.19 (-0.10-0.47)

NRS 2002, Nutritional Risk Screening 2002: NRS 2002 ≥ 3: nutritional risk; SGA, Subjective Global Assessment: SGA B + C: malnutrition; BMI, Body Mass Index: BMI < 18.5 kg/m^2: malnutrition; TLC, Total Lymphocytes Count: TLC < 1,200 mm^3: malnutrition; SPA, Standardized Phase Angle: SPA < 0.8: malnutrition.
[a]95% confidence interval.
[b]There were 20 values ignored for this variable.

The agreement between the SPA and NRS 2002, SGA, BMI and TLC in the diagnosis of malnutrition is shown in table III. The results show poor to weak agreements. The highest (weak) agreement was found between SPA and SGA (0.27; CI95% 0.06-0.48), followed by NRS 2002 and TLC [(0.25; CI95% 0.04-0.46) and (0.22; CI95% -0.02-0.46), respectively]. The lowest (poor) agreement was seen between SPA and BMI (0.01; CI95% -0.13-0.14). Men presented weak agreement between SPA and NRS 2002, SGA and TLC [(0.33; CI95% -0.01-0.68), (0.39; CI95% 0.04-0.73) and (0.29; CI95% -0.11-0.69), respectively]. Meanwhile, among women only the SGA presented weak agreement with SPA (0.21; CI95% -0.04-0.47).

Table IV shows the mean values for SPA according to categories of nutritional status based on parameters of nutritional status assessment. Malnourished patients diagnosed by NRS 2002, SGA and TLC had a significantly lower mean SPA (-0.7, -0.7 and -1.0, respectively) as compared to those who were well-nourished (0.0, 0.0 and -0.2, respectively). Men who were malnourished according to NRS 2002, SGA and TLC had significantly lower mean SPA than well-nourished men. Among women, just those diagnosed as malnourished by NRS 2002 had significantly lower mean SPA values than the well-nourished women.

The cut-off point of 0.8 for standardized phase angle presented a sensitivity of 82.6% (CI95% 65.0-100.0%) and a specificity of 40.6% (CI95% 23.0-58.2) (fig. 1).

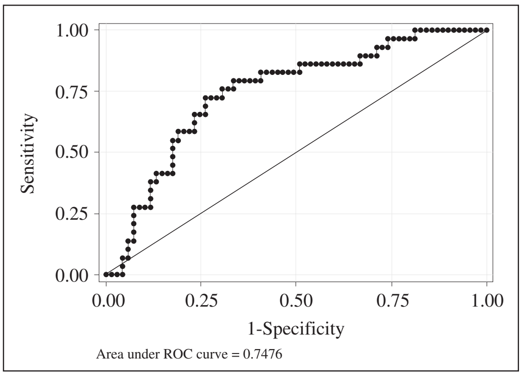

Fig. 1.—ROC (Receiver Operating Characteristic) curve for the best cut-off point of the phase angle for malnutrition, using SGA as the reference method (n = 98).

We found a percentage of 23.5% of malnourishment by means of standardized PA (SPA), while in another study the prevalence of malnutrition was 73.9%.[6] Other work has shown that in patients undergoing elective gastrointestinal surgery, for whom a cut-off point of PA < 5 was considered, the prevalence of malnutrition was 18.5%.[23] It should be noted that it is difficult to assess such patients due to the lack of reference values for this parameter.[24] As a result, different cut-off points have been used for the diagnosis of malnutrition in each study, which in turn makes it difficult to compare the results of different studies.

Discussion

The importance of the phase angle (PA) is evident in many clinical situations.[20] The PA, as a predictor of body cell mass (BCM), has been evaluated as a marker of nutritional status in adults and children,[10,21,22] making it relevant to investigate whether lower values for PA could be interpreted as malnutrition,[11] as proposed in our study.

The most notable agreement in the diagnosis of malnutrition, although still weak, was found between SPA and SGA (0.27), with this being greater amongst men than women. The study by Barbosa-Silva and colleagues [23] reported an agreement of 0.39 between PA and SGA, which was similar (0.33) to that obtained in a study conducted in patients with advanced colorectal cancer.[25]

In our study, malnutrition defined by a SPA below 0.8 did not show good agreement with the methods investigated. The higher agreement found between

Table IV
Mean values of the standardized phase angle (SPA) according to the classes of nutritional status diagnosed by Nutritional Risk Screening (NRS 2002), Subjective Global Assessment (SGA), Body mass index (BMI) and Total Lymphocytes Count (TLC), according to sex (n = 98)

Method	*PA (whole sample)*		*p-Value*	*PA (men)*		*p-Value*	*PA (women)*	
	Mean	*(CI[a])*		*Mean*	*(CI[a])*		*Mean*	*(CI[a])*
NRS 2002			0.001[b]			0,03[b]		
< 3	0.0	(-0.2-0.3)		0.0	(-0.4-0.4)		0.0	(-0.3-0.3)
≥ 3	-0.7	(-1.2-0.2)		-0.9	(-1.9-0.0)		-0.6	(-1.2-0.0)
SGA			0.001[b]			0.002[b]		
A	0.0	(-0.2-0.3)		0.1	(-0.4-0.6)		0.0	(-0.3-0.3)
B + C	-0.7	(-1.1-0.4)		-1.2	(-1.8-0.6)		-0.5	(-0.9-0.1)
BMI (kg/m^2)			0.2[c]			0.3[c]		
≥ 18.5	-0.2	(-0.4-0.1)		-0.2	(-0.7-0.2)		-0.1	(-0.4-0.1)
< 18.5	-0.8	(-2.1-0.4)		-1.2	(-10.0-8.4)		-0.5	(-4.4-3.5)
TLC[d] (mm^3)			0.03c			0.02c		
≥ 1,200	-0.2	(-0.4-0.1)		-0.1	(-0.6-0.4)		-0.2	(-0.5-0.1)
< 1,200	-1.0	(-2.0-0.1)		-1.8	(-4.7-1.1)		-0.7	(-1.8-0.5)

NRS 2002, Nutritional Risk Screening 2002: NRS 2002 < 3 normal nutrition; NRS 2002 ≥ 3: nutritional risk; SGA, Subjective Global Assessment: SGA A: normal nutrition; SGA B + C malnutrition; BMI, Body Mass Index: BMI ≥ 18 kg/m^2: normal nutrition; BMI < 18.5 kg/m^2 malnutrition; TLC; Total Lymphocytes Count TLC ≥ 1,200 mm^3: normal nutrition; TLC < 1,200 mm^3: malnutrition; SPA, Standardized Phase Angle:
[a]95% confidence interval.
[b]Student's *t*-test for comparison of values between categories for independent variables.
[c]Mann-Whitney test for comparison of values between categories for independent variables.
[d]There were 20 values ignored for this variable.

SPA and SGA might be explained by the fact that SGA is associated with abnormal tissue structure as well as loss of body mass, and that these altered electrical tissue properties are not detected by the other methods.[6,9,11] In addition, both techniques have revealed a prognostic function in previous work in the literature. SGA predicted complications related to nutritional status in numerous populations of hospitalized patients, including surgical patients.[5,13] The PA, in turn, was described as a prognostic index for complications in patients undergoing elective gastrointestinal surgery,[6] as well as for patients on haemodialysis,[20,21] on peritoneal dialysis,[26] with cancer,[7] with cirrhosis[28] and who were HIV+ (human immunodeficiency virus positive).[29] However, it has been questioned whether SGA and PA are indicators of the severity of disease merely because of their relationship with malnutrition.[21] Thus, other studies should seek to determine whether SGA and the PA represent wider indicators of general health or simply nutritional markers.

The lowest value for agreement was found between SPA and BMI. This result was probably due to the elements of BIA, such as PA, and anthropometric markers, such as BMI, that express different aspects and stages of nutritional deficiency. According to Edefonti et al.,[30] BIA is more sensitive than anthropometry in detecting changes in body composition, and consequently cases of malnutrition may be identified at an earlier stage using this method. This is supported by the fact that in patients with tumours of the head and neck, with normal BMI, the PA was reduced before the appearance of ostensible signs of cachexia and weight loss.[31]

Considering the distribution of the mean values of SPA according to the classes of nutritional status of patients diagnosed by the investigated methods, a decrease in the mean SPA values became apparent in malnourished patients, with a significant difference in relation to patients identified as well-nourished by NRS 2002, SGA and TLC. Among women, this difference in mean SPA was seen only for categories of NRS 2002. These results could be associated with a large number of the male patients having malignant gastrointestinal tumours, while women presented a higher proportion of benign pancreatic or biliary tract disease.

To our knowledge this is the first study to show an association between the PA and TLC and with the screening instrument NRS 2002. In relation to TLC, although this was determined in a smaller number of patients, the difference in mean SPA values between malnourished and well-nourished patients might be explained by the effect on this marker of non-nutritional conditions, such as the presence of an underlying disease. As a result we cannot state with certainty that the PA is indicating the patients' nutritional status exclusively. SPA decreased significantly with poor nutritional status, according to SGA and NRS 2002, indicating the ability of PA to detect changes in nutritional status prior to any alteration in anthropometrical measurements. With regard to the SGA, this finding had been previously shown in other studies.[9,23,25] Meanwhile, although our study did not find significant differences in mean SPA values between patients diagnosed as malnourished and well-nourished by BMI, a study conducted in surgical patients,[24] one in patients with benign gastrointestinal disease[9] and another performed in patients undergoing haemodialysis,[21] reported that the mean PA was significantly lower in patients with a lower BMI, when compared to those a with higher BMI.

The lower mean SPA values observed in malnourished patients may indicate its tendency to reflect a compromised nutritional status. According to Maggiore and colleagues,[21] BIA parameters, including the PA, tend to be altered in the presence of severe malnutrition resulting from various pathological states. In this way, although the PA did not present good agreement with methods of assessment of nutritional status, our findings do suggest the capacity of BIA, through the PA, to detect changes in nutritional status.

A specific cut-off level of PA that would help in the assessment of hospitalized patients and to identify if patients are either well-nourished or malnourished remains unavailable. Therefore, it is necessary to choose a cut-off point that closely matches the sensitivity and specificity of the traditional nutritional tests. In the present study, this goal was achieved by evaluating PA against SGA.

The use of SPA, in the present study, in diagnosing malnutrition showed greater sensitivity than specificity. According to Barbosa-Silva et al.,[23] the cut-off point of 5 for both sexes exhibited sensitivity of 31% and 47%, and specificity of 97% and 94% for men and women, respectively. In patients undergoing haemodialysis, the relationship between SGA and the quartiles for PA, when analysis was limited to the lower quartile, presented a sensitivity of 67% and a specificity of 78%.[21]

In our study, considering the cut-off point of 0.8 for SPA, we could not find simultaneously high levels of sensitivity and specificity. The cut-off point for SPA that showed the best result for the whole sample was 0.63 (72.4% sensitivity and 68.1% specificity).

Overall, it is difficult to provide a complete explanation of the results found since the biological significance of the PA has yet to be thoroughly elucidated.[6,21,26] One explanation that might be considered is that PA and SGA capture different aspects of nutritional status and, thus, they should be used as complementary tests to each other in nutritional assessment.[25]

The limitations of the present investigation include the size of the sample, which was relatively small, and the fact that it was composed of a specific group of patients, thereby restricting the generalization of the findings. It has been suggested that the direct bioimpedance measures (R, Xc and PA) vary depending on age, gender and body mass characteristics of the study population.[17] Nevertheless, the use of the SPA, in the present study, was important in order to make the values comparable with different populations. In addition, the *k* test performed better in men than women suggesting that different cut-off points for each sex would result in better findings.

Considering that treatment should maintain or lead to a gain of BCM, as a metabolically active component of the lean tissue,[10] PA may be a useful parameter to assess the effectiveness of nutritional therapy.[8]

In conclusion, the SPA presented a weak agreement with the methods of nutritional assessment investigated, as well as low specificity, and could not be recommended as a marker of nutritional status according to our results, despite the fact that the lowest values for SPA were found in malnourished patients.

These data will need to be corroborated by future studies for a more complete understanding of the exact value of PA as an indicator of nutritional status, as well as for monitoring dietary interventions. Finally, it is necessary to produce reference values for different populations.

Acknowledgements

The authors are grateful to Professor Francisco de Assis Guedes de Vasconcelos, for the loan of the Bioelectrical Impedance apparatus, and the Post-Graduate Program in Nutrition of the Federal University of Santa Catarina. We thank the patients and staff of the University Hospital of the Federal University of Santa Catarina. Financial support was obtained through the Fundo de Incentivo a Pesquisa of the Federal University of Santa Catarina-FUNPESQUISA, and a scholarship from the Fundação de Apoio à Pesquisa Científica e Tecnológica do Estado de Santa Catarina-FAPESC (Prêmio Mérito Universitário, call for applications n 05/2006).

Statement of authorship: LS was responsible for the conception and design of the study, the collection and interpretation of data, and drafted and wrote the manuscript. EW was responsible for the conception, design and coordination of the study, and interpretation of data, and also helped with drafting and revision of the manuscript. JLB carried out the analysis and interpretation of data, and helped to draft and revise the manuscript. TRC carried out the interpretation of data and revision of the manuscript. LMN carried out the interpretation of data and revision of the manuscript. All authors read and approved the final manuscript.

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