ORIGINAL ARTICLE

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Predictive value of bioelectrical impedance analysis parameters in the mortality of patients on haemodialysis

Valor preditivo dos parâmetros de bioimpedância na mortalidade dos doentes em hemodiálise

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ABSTRACT

Background: Protein-energy wasting is a very common complication in hemodialysis patients and influences their survival. All hemodialysis patients should have their nutritional status evaluated regularly using multiple methods. The bioelectrical impedance analysis has been widely used in the nutritional assessment. The objective of this study was to evaluate, for a period of 7 years, to the prognostic value of the parameters of bioelectrical impedance analysis on mortality in hemodialysis patients. **Methods:** A retrospective, observational study, including 301 patients in hemodialysis at baseline. During the study period 96 patients died, 46 patients were transplanted, 21 were not followed by Nutritionist, 49 were transferred to another clinic and 4 underwent treatment changes. The parameters assessed at baseline were: demographic and clinic data (age, gender, etiology of chronic kidney disease and co-morbidity), dialysis data (type and duration of hemodialysis, dialysis vintage, vascular access and Kt/V), biochemical parameters, body mass index, bioelectrical impedance analysis, subjective global assessment and PNAn. **Results:** According to Kaplan-Meier, Mantel-Hansel and Cox regression analysis the following variables were predictors of mortality: age, dialysis vintage, body mass cell index‹8 kg/m^2, phase angle‹4.9º, extracellular mass/body cell mass ratio and PNAn‹1.2 g/kg/day were selected as potential predictors of mortality. In multivariate analysis, after adjusting for others mortality risk factors (age, dialysis vintage, serum albumin, PNAn, inflammatory state, presence of diabetes and cardiovascular co-morbidity), only patients with lower phase angle were found to be at high risk for mortality. **Conclusion:** The present study shows that bioelectrical impedance analysis parameters (phase angle, body mass cell index and extracellular mass/body cell mass ratio) and PNAn were the only nutritional markers associated with

mortality in this cohort of hemodialysis patients. Therefore we conclude that the bioelectrical impedance analysis is a promising technique for assessing the nutritional status of patients on hemodialysis and may be used as a prognostic indicator of mortality in this population.

Key-words: Bioelectrical impedance analysis; mortality; nutritional assessment; protein energy wasting.

RESUMO

Introdução: A desnutrição proteico-energética é uma complicação comum nos doentes em hemodiálise e influencia a sua sobrevivência. A avaliação nutricional deve ser feita regularmente em todos os doentes utilizando vários métodos. A bioimpedância tem sido amplamente utilizada na avaliação nutricional destes doentes. O objetivo deste estudo é avaliar o valor prognóstico dos parâmetros da bioimpedância na mortalidade dos doentes em hemodiálise, durante um período de 7 anos. **Métodos:** Estudo retrospectivo, observacional**,** que incluiu, no início do estudo, 301 doentes em hemodiálise. Durante o período de estudo 96 doentes faleceram, 21 não foram seguidos por Nutricionista, 46 foram transplantados, 49 foram transferidos de clínica e 4 de tratamento. Parâmetros avaliados no início do estudo: dados demográficos e clínicos (idade, género, etilologia da doença renal e comorbilidades), dados da diálise (tipo e duração da hemodiálise, tempo, acesso vascular e Kt/V) bioimpedância, avaliação subjetiva global, parâmetros bioquímicos, índice de massa corporal e PNAn. **Resultados:** De acordo com a análise de Kaplan-Meier, Mantel-Haenszel e regressão de Cox, foram considerados preditores de mortalidade os seguintes parâmetros: idade, tempo de diálise, índice de massa celular‹8kg/m², ângulo de fase‹4.9º, relação água extracelular/massa celular e PNAn‹1,2g/kg/dia. Na análise multivariada, depois do ajuste da mortalidade para outros parâmetros (idade, tempo de diálise, albumina sérica, PNAn, estado inflamatório, presença de diabetes e co-morbilidades cardiovasculares) apenas o ângulo de fase foi considerado um preditor de mortalidade no período estudado. **Conclusão:** Neste estudo os parâmetros avaliados por bioimpedância (ângulo de fase, índice de massa celular e relação água extracelular/massa celular) e a PNAn são marcadores nutricionais associados com a mortalidade nesta amostra. Concluímos que a bioimpedância constitui uma técnica promissora de avaliação do estado nutricional dos doentes em hemodiálise, podendo ser utilizada como indicador de prognóstico de mortalidade nesta população.

Palavras-chave: Avaliação nutricional; bioimpedância; desnutrição proteico-energética; mortalidade.

INTRODUTION

Protein energy wasting (PEW) is extremely common in hemodialysis (HD) patients. Several studies have shown that nutritional markers are associated with patient survival in HD[1,2]. As no single clinically applicable parameter provides a conclusive indication of protein-energy nutritional status, international guidelines recommended the use of multiple nutritional markers[3,4]. The International Society of Renal Nutrition and Metabolism (ISRNM) published a consensus statement defining which elements describe protein-energy nutritional status[4]. It describes four categories: serum chemistry, body mass, muscle mass and dietary intake. Thus, assessment of body composition should be made through techniques such as Dual-energy X-ray absorptiometry (DEXA), bioelectrical impedance analysis (BIA) or anthropometry[5]. While DEXA are not readily available in daily practice, BIA is an evolving method for longitudinal cross sectional assessment of nutritional status[5]. BIA is a useful but disputed method for quantifying body composition. In HD patients with daily changing hydration status it is difficult to

evaluate malnutrition. BIA is based on electrical properties of biological tissues, where impedance is the measure of the opposition to the flow of an alternating current and expressed by tissue resistance and reactance[6,7]. Impedance is low in lean tissues, where intra and extracellular fluids and electrolytes are primarily contained, and high in bone, air-filled space and adipose tissue. In general, impedance is proportional to total body water. The phase angle (PA) is derived from the tangent arch, between reactance and resistance, measured by BIA, so it does not depend on parameters such as the height and weight of the patient. Smaller PA suggests cell death or decreased cell integrity, whereas larger PA suggests higher quantities of intact cell membranes. It can also be interpreted as an indicator of water distribution between the extra and intracellular spaces. The PA has been found to be a prognostic marker in several clinical conditions such as the human immunodeficiency virus infection, liver cirrhosis, chronic obstructive pulmonary disease, sepsis, cancer, systemic sclerosis and HD patients[8]. The body cell mass (BCM), which is a metabolically active component of fat-free mass (FFM), is the single best predictor of patients' nutritional status. The body cell mass index (BCMI), which is calculated from BCM dividing by height squared (kg/m^2), has been shown to be more sensitive to changes in protein status and lean tissue compared to body mass index (BMI). The muscle mass (MM) depletion in certain pathologic conditions can be best described by the loss of BCM[9]. Extracellular mass (ECM) contain all the body´s metabolically active tissues. Extracellular mass/body cell mass ratio (ECM/BMC) is a highly sensitive index of malnutrition and hydration[10]. The current study aimed to evaluate the relationship between nutritional markers determined by BIA and other nutritional markers and assess the prognostic value of the parameters of bioelectrical impedance analysis on mortality in HD patients.

SUBJECTS AND METHODS

An observational, retrospective, multicenter study, to assess the nutritional status of 301 patients on HD. The patients mean follow up was 56.8±29.2 months (min. 2; max. 84 months) between 2004 and 2011.

Sample: At baseline (year 2004) 394 HD patients were randomly selected from dialysis centres located in Mirandela, Gondomar, Porto and Santa Maria da Feira. Exclusion criteria were: serum albumin ‹ 2.6 g/dl, pace-maker, asymmetrical patients (such as amputees), dermatological diseases, or patients with creatinine clearance › 5.0ml/min/1.73m^2. All patients have received detailed nutritional information by Nutritionist and have signed an informed consent. There were included in the study only 301 patients. During the study period (2004-2011): 96 patients died, 46 patients were transplanted, 21 were not followed by Nutritionist, 49 were transferred to another clinic and 4 underwent treatment changes.

Demographic and clinic data: age, gender, etiology of chronic kidney disease and presence of co-morbidity.

Dialysis data: type of HD, dialysis vintage, duration of HD and vascular access. The adequacy of dialysis was calculated by single-pool Kt/V.

Laboratory procedure: We measured the predialysis serum concentrations of: serum albumin_ Alb, total cholesterol_ Tcol, serum creatinine_ Creat, C-reactive protein_ CRP; using standard laboratory techniques. Inflammatory state was considered present when the value of CRP was higher than 0.6 mg/dl. The measurement of dietary protein intake was the normalized protein nitrogen appearance (PNAn), calculated using the equation published by National Kidney Foundation (NKF) and Kidney Disease and Dialysis Outcome Quality Iniciative (K/DOQI)[3].

Anthropometric measurements: body weight, height, body mass index_ BMI (calculated based on dry weight).

Bioelectrical impedance analysis: was performed before and after a mid-week dialysis, with a portable derivate model BIA 101, using Bodigram S.R.I. Bioresearch® – AKERN v.1.3. In order to determine resistance (R) and reactance (XC), the patient received an electrical current of 800 µA at 50 kHz. The software calculated the following parameters: phase angle_ PA (º), ECM/BCM, BMC (kg and %), FFM (kg and %), body fat _ BF (kg and %), MM (kg and %) and BCMI (kg/m^2).

Subjective global assessment: SGA was guided by a scale of 7 points (NECOSED). Patients with adequate nutritional status patients were classified with scores between 6 and 7, mild or moderate PEW received scores between 3 and 5 and severe PEW received scores between 1 and 2.

The study was approved by the Ethic Committee of Faculty of Medicine, University of Porto/"Hospital São João" (CHSJ), Porto, Portugal and (at baseline, in year 2004) by the ethic committee of Fresenius Medical Care (Portugal).

Statistical analysis: The results were expressed as mean ± standard deviation or in absolute and relative frequency (n, %). The program SPSS 21.0 ® for Windows (IBM) was used to calculations t-Student test, Mann-Whitney for independent samples, compared by sex and survivor and non survivor groups, and the degree of association between the variables by Pearson's correlation coefficient (r). The outcome of interest in the present study was mortality. Odds ratios and 95% confidence interval were calculated. The Kaplan-Meier method was used to calculate cumulative survival probabilities, and the difference between survival curves was assessed by long-rank test. Cox´s proportional hazards model (backward method) was used to evaluate independent predictors of survival. Hazard ratios (HR) and 95% confidence intervals (95% CI) were calculated. Difference was considered statistically significant when two-tailed p value was less than 0.05.

RESULTS

Descriptive results

At baseline, the study included 301 patients (185 men, 116 women) with average age 62.3 ± 13.9 years old. These patients were in HD for about 4.8 ± 4.5y. The prevalence of diabetes was 25.9% in all patients. Most patients performed high flux HD (72.1%), three times/week (95,3%), with an average of 11.5±1,1 hours of HD per week.

During the period of study 96 patients have died (53%), 46 patients (15.2%) were transplanted, 21 (6,9%) were not followed by Nutritionist, 49 (16.2%) were transferred to another clinic and 4 (1.4%) underwent treatment change. The results shown are from the study of a total of 181 patients on HD therapy (99 men, 82 women) with average age 65.8 ± 12 years old. The causes of end-stage renal disease were diabetic nephropathy (23.2%), hypertensive nephrosclerosis (11.6%) and others (65.2%). Regarding HD access, 82.9% of patients had a native arteriovenous fistula and 17.1% had a central venous catheter. Most patients performed high flux HD (87.8%), three times/week (95%) for 4 hours. The median dialysis vintage was 3.9 years (range: 0.5 to 24.4 years). Demographic, laboratory and nutritional data of incident HD patients are presented in following table (Table I).

The prevalence of PEW varies according to the criteria used for its diagnosis (SGA<6 points: 11%; Alb<4.0 g/dl: 68%; Alb<3.8 g/dl: 29.3%; Alb<3.6 g/dl: 13.3%; Tcol<150 mg/dl: 46.4%; Tcol<100 mg/dl: 5.5%, BMI<23 kg/m^2: 40.3%, BMI<18.5 kg/m^2:2.8; BCMI<8.0 kg/m^2: 49.7%; PA<6.4º:78.5%; PA<6º:65.2%; PA<4º:7.2%.

Thirty-seven point four percent of patients have inflammatory state (CRP>0.6 mg/dl).

Fifty-nine percent of patients (n=107) had a BMI between 18.5 and 25 kg/m^2, 38.1% (n=69) were overweight or obese (BMI≥25 kg/m^2), and only 2.8% (n=5) were underweight. Comparing male and female groups, Creat, FFM (%) and dialysis vintage were significantly lower in female group. In contrast, Tcol, BMI, BF (%) and Kt/V were higher in this group.

No difference was observed in serum albumin concentration, SGA, PA, BCM, BCMI and ECM/BCM ratio. Dietary protein intake was similar between male and female groups. However, in 57,5% of patients the protein intake was below the recommendation[3].

Association between nutritional marker assessed by BIA and other nutritional parameters

The PA, assessed by BIA, correlates positively with: Alb (r=0.40; p<0.001), Creat (r=0.30; p<0.001),

Table I

Patient characteristics (n=181)

Parameters	Total (n =181)	Male (n = 99)	Female (n = 82)	*p*; p**
Demographic				
Age (years)	65.8±12.0 (Median = 68 y)	65.3±12.0 (Median = 67 y)	66.3±12.0 (Median = 69 y)	n.s *
Parameters of protein-energy nutritional status				
SGA Classification ‹6	6.6 ± 0.4	6.5 ± 0.4	6.6 ± 0.4	n.s.*
Well nourished	161 (89%)	88 (88.9%)	73 (89%)	n.s.**
Mild to moderate malnutrition	20 (11%)	11 (11.1%)	9 (11%)	n.s.**
Severe malnutrition	0 (0%)	0 (0%)	0 (0%)	n.s.**
Serum albumin (g/dl)	3.8 ± 0.3	3.8 ± 0.2	3.8 ± 0.3	n.s.*
Alb ‹ 4.0 (n; %)	123 (68%)	53 (64.6%)	70 (70.7%)	n.s.**
Alb ‹ 3.8 (n; %)	53 (29.3%)	22 (26.8%)	31 (31.3%)	n.s.**
Alb ‹ 3.6 (n; %)	24 (13.3%)	13 (15.9%)	11 (11.1%)	n.s.**
Serum creatinine (mg/dl)	8.6 ± 2.5	8.9 ± 2.5	8.3 ± 2.3	n.s.*
Total cholesterol (mg/dl)	152.8±34.5	147.2±36.5	159.4±30.8	‹0.05*
Tcol ‹ 150 (n; %)	84 (46.4%)	50 (50.5%)	34 (41.5%)	n.s.**
Tcol ‹ 100 (n; %)	10 (5.5%)	9 (9.1%)	1 (1.2%)	‹0.05**
PNAn (g/kg/day)	1.0 ± 0.2	1.0 ± 0.1	1.1 ± 0.2	n.s.*
PNAn ‹ 1.2 (n; %)	104 (57.5%)	61 (61.6%)	43 (52.4%)	n.s.**
Body mass index (kg/m²)	24.3±3.8	23.5±3.3	25.4±4.3	‹0.01*
BMI ‹ 23 (n; %)	73 (40.3%)	47 (47.5%)	26 (31.7%)	‹0.05**
Phase angle (º) _BIA	5.6 ± 1.2	5.6 ± 1.4	5.5 ± 1.0	n.s.*
PA ‹ 6.4 (n; %)	142 (78.5%)	75 (75.8%)	67 (81.7%)	n.s.**
PA ‹5.9 (n; %)	110 (60.8%)	57 (57.6%)	53 (64.6%)	n.s.**
PA‹5.5 (n;%)	85 (47%)	47 (47.5%)	38 (46.3%)	n.s.**
PA‹4.9 (n; %)	13 (7.2%)	26 (26.3%)	15 (18.3%)	n.s.**
Body mass cell mass (kg/m²) – BIA	7.6±1.9	7.5±1.9	7.7±1.8	n.s.*
BCMI ‹ 8	90 (49.7%)	55 (55.6%)	35 (42.7%)	n.s.**
Body Fat (%)	32.9±9.0	29.5±8.0	37.1±8.6	‹0,001*
Fat-free mass (%)	67.0±9.0	70.5±8.0	62.9±8.7	‹0,001*
Body mass cell (kg)	22.0±6.9	23.4±7.3	20.5±6.0	n.s.*
Extracellular mass/body cell mass ratio	1.0±0.2	1.0±0.2	1.0±0.2	n.s*
Other clinical parameters				
Dialysis vintage (years)	4.9±4.7 (Median=3.9 y)	5.5±4.9 (Median=4.3 y)	4.2±4.2 (Median=2.8 y)	‹0.05*
Kt/V	1.6±0.3	1.5±0.3	1.6±0.3	‹0.05*
C-reactive protein (mg/dl)	1.0±1.3 (Median= 0.5)	0.9±1.1 (Median= 0.5)	1.0±1.5 (Median= 0.5)	n.s.*
CPR › 0.6	69 (38.1%)	31 (37.8%)	38 (38.4%)	n.s.**

Note: Value are expressed: mean ± standard deviation and frequency (n, %)

p* test t-Student for independent samples, compared by sex; p** test Mann-Whitney for independent samples, compared by sex. Abbreviations: n.s., no significance

SGA (r=0.56; p‹0.001) and BMI (r=0.28; p‹0.001). Correlates negatively with CRP (r= -0.12; p‹0.001).

The BCMI correlates positively with: Alb (r=0.45; p‹0.001), Creat (r=0.34; p‹0.001), SGA (r=0.54; p‹0.001) and PNAn (r=0.31; p‹0.001). Correlates negatively with CRP (r=-0.16; p‹0.001).

The ECM/BCM ratio correlated inversely with: Alb (r= – 0.35; p‹0.001), Creat (r= -0.99; p‹0.001), SGA (r= -0.47; p‹0.001) and PA (r= -0.74; p‹0.001).

Comparison between survivors and non survivors

Comparing survivor and non survivor groups, age, dialysis vintage, ECM/BCM and CPR were significantly higher in non survivor group. In contrast, BCMI, PA and PNAn were lower in this group. No difference was observed in: sex, presence of diabetes, SGA, BMI, laboratory parameters (Alb, Creat and Tcol), dose of dialysis and BIA parameters (BF, FFM and BMC). All characteristics of survivor and non survivor patients was presented in Table II (Table II).

Table II

Comparison between survivor and non-survivor patients

Parameters	Survivor (n = 85)	Non- survivor (n = 96)	*p*; p***
Demographic			
Gender (M/F) n (%)	42 (49.4%) F 42 (49.4%) M	40 (41.7%) F 56 (58.3%) M	n.s.*
Diabetes (%)	27.1%	30.2%	n.s.*
Age (Years)	62.2 ± 13.2	68.9 ± 9.8	‹ 0.001**
Dialysis vintage (years)	4.2 ± 4.4 (Median = 2.8 y)	5.6 ± 4.7 (Median = 3.9 y)	‹0.05**
Parameters of protein-energy nutritional status			
SGA (1-7 point)	6.7 ± 0.4	6.6 ± 0.4	n.s.**
Serum albumin (g/dl)	3.9 ± 0.3	3.8 ± 0.3	n.s.**
Serum creatinine (mg/dl)	8.9 ± 2.7	8.4 ± 2.1	n.s.**
Total cholesterol (mg/dl)	155.2±35.8	150.6±33.4	n.s**
Body mass index (kg/m²)	24.6 ± 4.2	24.1 ± 3.5	n.s.**
Phase angle (º) _BIA	5.9 ± 1.4	5.2 ± 0.9	‹0.001**
Body mass cell index (kg/m²) – BIA	8.2 ± 2.2	7.0 ± 1.2	‹0.001**
Body Fat (%)	33.2 ± 8.7	32.8 ± 9.3	n.s.**
Fat-free mass (%)	66.8 ± 8.8	67.2 ± 9.3	n.s.**
Body mass cell (kg)	22.8 ± 7.0	21.4 ± 6.7	n.s.**
Extracellular mass/body cell mass ratio	0.9 ± 0.2	1.1 ± 0.2	‹0.001**
Parameters of dialysis dose			
Kt/V	1.6 ± 0.3	1.5 ± 0.3	n.s.**
Parameters of protein ingestion			
PNAn (g/kg/day)	1.1 ± 0.1	1.0 ± 0.2	‹0.001**
Parameters of inflammation			
C-reactive protein (mg/dl)	0.6 ± 0.6 (Median = 0.1)	1.3 ± 1.7 (Median = 1.0)	‹0.001**

Note: Values are expressed as Mean ± SD; *p Mann-Whitney test for independent samples, compared by groups; **p student's t test for independent samples, compared by groups; Abbreviations: n.s., not significant; F, Female; M, Male.

Patients 'survival and causes of death

The mean survival time of patients was 32.7±19.3 months, median 28.5 (range: 2 months to 6.25 years). The major causes of death were cardiovascular disease (35.4%) and infections (15.6%), all other causes accounting for the remainder 49%.

Survival analysis

The influence of initial variable on mortality of the patients is shown in Table III.

Age over 60 years, Alb (lower than 3.8 g/dl), PA (lower than 4.9º) and BCMI lower than 8 kg/m² were significantly associated with increased mortality. In contrast, gender and presence of diabetes did not influence mortality. Finally, protein intake lower than 1.2 g/kg/day and inflammatory state (CPR›0.6 mg/dl) were also associated to reduced survival. Concerning the BIA parameters, PA (lower than 4.9º) and BCMI lower than 8 kg/m² negatively influenced the survival, as shown in Figure 1 (Fig. 1).

Table III

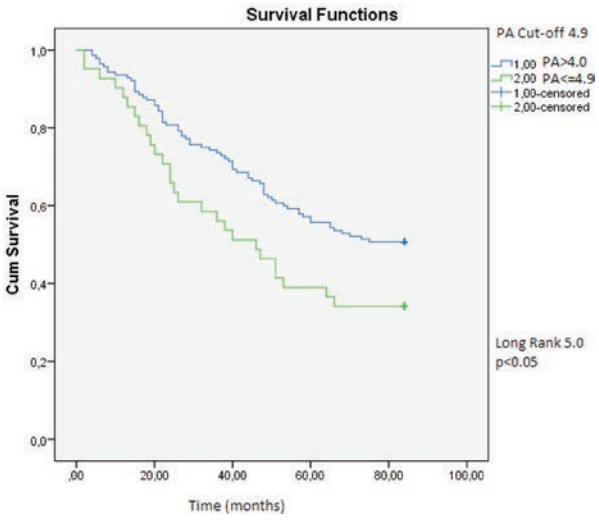
Influence of initial variable on mortality of patients

Parameters	Odds Ratio	95% CI	p
Sex	0.7	0.4-1.3	n.s.
Diabetes	0.9	0.4-1.6	n.s.
Smoking	4.8	1.0-23.6	‹ 0.05
Age ≥ 60 years	0.4	0.2-0.7	‹ 0.01
Dialysis vintage ≥ 2 years	0.4	0.2-0.7	‹ 0.01
Alb ≤ 3.8 g/dl	1.9	0.9-3.7	‹ 0.05
PA ≤ 4.9º	0.5	0.2-1.0	‹ 0.01
BCMI ≤ 8 kg/m²	3.4	1.8-6.2	‹ 0.01
PNAn ≤ 1.2 g/kg/day	2.7	1.5-4.9	‹ 0.01
CRP › 0.6 mg/dl	0.2	0.1-0.5	‹ 0.001

Mantel-Hansel odds ratio; Abbreviations: CI, confidence interval

Figure 1

Kaplan-Meier proportion of surviving patients comparing subgroups of severity according PA-BIA (cut-off PA = 4.9º) in 181 prevalent HD patients.



In the univariate analysis, general factors including age (HR:1.038; 95% CI, 1.005 to 1.071; p‹0,05), dialysis vintage (HR:1.070; 95% CI 1.009 to 1.134; p‹0,05), cardiovascular co-morbidity (HR:3.961; 95% CI, 2.010 to 7.806; p‹0,01) and PNAn (HR:0.625; 95% CI, 0.395 to 0.995; p‹0,05) were all significant predictors of mortality. Among BIA nutritional parameters: BCMI (HR: 0.807; 95% CI 0.672 to 0,970; p‹0,05), PA (HR: 0.737; 95% CI, 0.557 to 0.975; p‹0,05) and ECM/BCM(log10) (HR: 36.362; 95% CI, 1.138 to 1161.744; p‹0,05) were also associated with reduced survival. The other parameter: SGA, presence of diabetes, Alb, CPR≥0.6 mg/dl and BMI, were not predictive of mortality. Selected for the multivariable Cox analysis variables were: age, dialysis vintage, PA, BCMI, presence of diabetes and cardiovascular co-morbidity, Alb, PNAn and CRP. As shown in Table IV, the PA was the only nutritional marker that was associated with mortality in the multivariate analysis.

Table IV

Cox Hazards analysis of factors predicting mortality

Parameters	B	Hazard Ratio	95% CI	p
Age (years)	0.340	1.038	1.005-1.071	‹ 0.01
Dialysis vintage (years)	0.651	1.070	1.009-1.134	‹ 0.05
Cardiovascular Co-morbidity	0.422	3.961	2.010-7.806	‹ 0.05
PA (º)	-2.753	0.737	0.557-0.975	‹ 0.05
CRP (mg/dl)	0.885	2.423	1.452-4.045	‹ 0.01

Cox proporcional Hazards analysis; Abbreviations: CI, confidence interval

DISCUSSION

Protein energy wasting (PEW) is a relevant problem in HD patients and is associated with an increased risk of mortality and morbidity[11-13]. This retrospective study was performed to evaluate the clinical importance of BIA nutritional markers with regard to the prediction of mortality.The average age of the sample was 65.8 years, higher than the average age of HD patients in European countries (between 58.1 and 62.2) and the United States of America (USA) (which is about 60 years). This study confirms that advanced age is a well-known risk factor in HD patients. For example, in the USA, the median life expectancy among patients starting dialysis is only 2.5 years, for ages between 65 and 69 years old is less than 1 year in ages ›=85 years old[14].

Diabetes was the primary cause of chronic kidney disease in the study sample, with 25.9% of diabetic patients. However, in this study, the diabetic condition did not influence the survival of patients. On the contrary, other studies have described Araujo et al., describe the presence of diabetes at the beginning of treatment, as an independent factor for the increase of the mortality rate in the following 10 years[15]. Hayashino et al. reported that diabetic patients on HD face a higher risk of mortality than nondiabetics (multivariate rate risk: 1.37, 95% CI, 1.08 to 1.74.)[16].

We found that patients with cardiovascular co-morbidity have a higher risk of mortality. The studies confirm higher cardiovascular risk death in HD patients, even after adjustment for age and the presence of diabetes. Heart failure is a rapidly lethal condition, in patients with ESRD, which appears to mediate most of the negative prognostic impact of ischemic heart disease. Abnormalities of the left ventricle are present at the start of dialysis in about 80% of dialysis patients. This foresees future ischemic

heart disease, heart failure and death after 2 years of dialysis treatment[17].

European[3] and American[18] recommendations advise the use of SGA as a tool for nutritional screening validity, for the population of patients in HD. The SGA has been used as the reference method, for the development of other instruments of nutritional screening[3,18]. This study reveals that 11% of patients suffer from moderate malnourishment because of SGA. Gurreebun et al. found similar results in the study of 141 patients on HD, with only 9.2% of malnourished patients[19]. The DOPPS20 (2004) study indicates that the prevalence of severe malnutrition according to SGA ranges from 2.3% (Italy) to 11% (USA). The prevalence of moderate malnutrition ranges between 7.6% (USA) to 18% (France). In the USA sample, severely and moderately malnourished patients faced a higher mortality risk compared with those not malnourished, 33% and 5% higher, respectively[20]. Chan et al. studied 167 HD patients and found that age, hypoalbuminaemia and SGA scores are independent predictors of mortality. Compared with being well nourished (SGA = A), malnourishment with normal or low Alb was associated with higher risk of mortality (HR: 2.06; 95% CI, 1.06 to 4.00; p=0.03 and HR: 2.86; 95% CI, 1.65 to 4.94; p<0.0001, respectively)(21). However, this study demonstrated that the SGA is not a predictor of mortality in patients with HD. Others studies have demonstrated that decreased SGA was an independent predictor of mortality in hemodialysis patients[34,35]. On the other hand, the DOPPS study found no relation between PNAn and survival in US patients[20].

Among the single laboratory markers, only CRP is a reliable prognostic parameter. Mutsert et al. studied 815 patients and found that in patients with either SGA score (HR: 1.6, 95% CI: 1.3 to 2.0), inflammation (HR:1.6, CI 1.3 to 2.0) or CVD (HR:1.7, 1.4 to 2.1) faced higher risk of mortality[22].

We also identified low dietary protein intake, as estimated by PNAn<1.2 g/kg per day, to be an independent risk factor for death. The influence on PNAn on survival of HD patients has been demonstrated by several previous studies[23-26].

The measure of BIA may be used for the detection of malnutrition as well as the body fluid status. The PA is derived from the tangent arch, between reactance and resistance, measured by BIA, and lower PA indicates low reactance, cell death, or loss of selective permeability of cell membrane[27,28]. Our study, the PA is correlated with other nutritional markers including Alb, Creat, SGA and BMI. Correlates negatively with CRP. Similar results were obtained in other studies[29-31]. PA and BCMI were significantly lower in the group of patients who do not survive. The low PA was identified as an independent factor for mortality risk, even when adjusted for other parameters such as age, dialysis vintage, cardiovascular co-morbidities, diabetes, inflammation and other nutritional markers (Alb and PNAn). The relation between PA and mortality has been demonstrated in many studies[30,32-34].

The BCMI is correlated with other nutritional markers including Alb, Creat, SGA and PNAn. It correlates negatively with CRP. The low BCMI was also identified as an independent risk factor for mortality but it did not enter the final Cox regression model, since it has a high correlation with PA (r=0,787). Talluri et al. describe BCMI as a more sensitive parameter than BMI to monitor changes in muscle mass and protein tissues, which might be associated with certain pathological conditions. Thus, a wide application of this index is recommended[35].

ECM/BCM ratio was significantly higher in the group of patients who do not survive. The ECM/BCM ratio correlated inversely with: Alb, Creat and SGA. The higher BCMI was also identified as an independent risk factor for mortality, but did not enter the final Cox regression model, since it has a high correlation with PA (r=-0.74; p<0.001). Avram et al. proposed the ECM/BCM ratio as prognostic marker in peritoneal dialysis patients. BCM reflects essentially muscle mass, whereas ECM corresponds to extracellular water. Thus, ECM/BCM ratios higher than 1.2 would indicate lower MM and/or fluid overload, which was associated in that higher mortality over follow-up of 8 years[10].

We conclude that the present study shows that BIA parameters (PA, BCMI and ECM/BCM ratios) and PNAn were the only nutritional markers associated with mortality in this sample of HD patients. In multivariate analysis, after adjusting for other mortality risk factors, only patients with lower PA were found to face high risk for mortality at follow-up.

Therefore we conclude that the bioelectrical impedance analysis is a promising technique for assessing the nutritional status of patients on haemodialysis and may be used as a prognostic indicator of mortality in this population.

Conflict of interest statement: None declared

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