

Biochemical and Bioimpedance Correlation with Quality of Life and Illness Perception in Hemodialysis Patients

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In hemodialysis patients malnutrition-inflammation syndrome, evaluated by biochemical laboratory analysis and through bioimpedance spectroscopy, was associated to impaired quality of life and with an increased risk of mortality. The present study goal was to investigate, in a cross-sectional analysis, performed in 122 hemodialysis patients, the association between biochemical parameters and bioimpedance-derived measurements the association of undernutrition with quality of life and illness perception. The results showed that our cohort perceived an impaired quality of life and illness perception and that these psychometric evaluation was associated with malnutrition markers.

Keywords: quality of life, hemodialysis, bioimpedance spectroscopy

Chronic kidney disease (CKD) is a severe, global, health concern and it is associated with increased risk of all-cause mortality, cardiovascular (CV) mortality and impaired quality of life (QoL) [1]. In the same manner, end-stage renal disease (ESRD) and renal replacement therapy (RRT) are associated with decreased QoL, decreased daily physical activity and performance, severe metabolic and CV complication and a negative illness perception (IP) all of these disturbances leading to a significant social, familial and professional impact [2-6].

Furthermore, patients receiving chronic hemodialysis (HD) treatment, have an increased mortality risk due to protein-energy wasting (PEW) syndrome and chronic systemic inflammation fluid overload (FO) status [7-10]. Also, a negative IP and QoL were previously found to be correlated to with malnutrition-inflammation syndrome and chronic overhydration in HD population [9].

A recent method to correctly evaluate body composition in RRT patients, that is non-invasive, easy and fast, is represented by the bioimpedance spectroscopy (BIS) [11]. Using a Body Composition Monitor (BCM Fresenius), important, predictive nutritional parameters, as lean tissue mass (LTM), adipose tissue mass (ATM) and fat mass (FM) can be independently evaluated, regardless of the hydration status of the patient [11].

There are several reports that associate a low body mass index (BMI), a low lean tissue index (LTI), overhydration expressed as measured overhydration (OH), or as relative overhydration (Rel. OH) as independent predictors for mortality in HD patients [9,12-15].

In the present study, we aimed to investigate the association of hematological, biochemical, clinical and BIS parameters with illness perception and quality of life in a cohort of hemodialysis patients.

Experimental part

Material and Method

Study Design and Patients Characteristics

An observational cross-sectional study was performed in stable HD patients in order to evaluate their illness perception and quality of life in association with hematological, biochemical, clinical, socio-demographical and BIS-derived parameters.

A total of 122 stable patients were included in the study (72 males and 50 females) who were receiving HD treatment three times weekly in Fresenius Nephrocure Iasi Dialysis Unit. The exclusion criteria were: age under 18 years old, ongoing acute illnesses, psychiatric illnesses, patients with pace-makers, amputees and patients who declined to participate in the study. All patients gave informed consent prior to participation.

Socio-demographical, laboratory analysis, clinical, therapeutically and HD-related parameters

For all included participants, the following parameters were collected: age, gender, living environment, CKD etiology, comorbidities and chronic medication.

All blood test were collected in the last three weeks prior to the study's initiation and development; also, all laboratory analysis were collected before the start of the mid-week HD session. The analyzed parameters included: serum hemoglobin (Hb) concentration, serum hematocrit (Ht) concentration, transferrin saturation (TSAT) values, serum alanine aminotransferase (ALT), serum alkaline phosphatase (AP), serum potassium (K), sodium (Na), bicarbonate (HCO_3), phosphorus (P), magnesium (Mg), total calcium (CaT) concentrations, serum intact parathyroid hormone (PTH) concentration, serum calcium-phosphorus product (CaXP), serum C reactive protein (CRP), serum ferritin, serum albumin, serum total cholesterol (CT), high-density lipoprotein cholesterol (HDL-CT), low-density lipoprotein cholesterol (LDL-CT) and triglycerides (TG) concentrations.

Blood pressure (BP) measurements were performed the HD session, using, for the present study, an average measurement of BP values obtained from the previous three consecutive HD sessions. HD-related parameters included: type of hemodialysis (conventional hemodialysis or hemodiafiltration (HDF)), dialysis vintage, vascular access (long-term catheter or arterio-venous fistula (AVF)) and dialysis adequacy expressed as Kt/V.

Assessment of body composition via BIS measurements

BIS measurements were obtained before the HD session, using a Body Composition Monitor (Fresenius Medical Care), a portable whole-body bioimpedance-

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analysis device working at 50 frequencies, over a range from 5 to 1000 KHz, in order to determine electrical tissue resistance and reactance (the high frequency current is able to pass through total body water (TBW), but the low frequency current can not pass through the cell membrane). The BCM measurements were obtained by trained medical staff, with the patient relaxed, in supine position, following an electrodes-placement protocol.

The following parameters were obtained: absolute, measured fluid overload (OH), Rel. OH (OH/ECW), extracellular water (ECW), intracellular water (ICW), ECW/ICW ratio, total body water (TBW), lean tissue mass (LTM), fat mass (FM), adipose tissue mass (ATM), body cell mass (BCM), body mass index BMI), lean tissue index, defined as LTM/height² (LTI), fat tissue index, defined as FTM/height² (FTI), LTM/weight ratio (LTM/W), ATM to weight ratio (ATM/W).

For normal range intervals, previous age, gender and height values, from references population, both general population and HD patients, were established, with values defined for LTI and FTI as low if LTI, or FTI is \leq 10th percentile of a reference population), high if LTI or FTI is \geq 90th percentile and normal if LTI or FTI is between the 10th and the 90th percentile of the reference population [14]. Also, the references ranges for OH were established between -1.1 l and 1.1 l, values under this interval defining underhydration and overhydration, respectively. Rel. OH was also found to be statistically significant associated with mortality in renal population, a value $>$ 15% being considered as severe overhydration being independently correlated with mortality in HD patients [15].

Illness Perception Evaluation

The Revised Illness Perception Questionnaire (R-IPQ) was used in the study population. The R-IPQ comprises five scales to assess the cognitive representation of the illness: timeline of the disease, perceived as acute or chronic (TI), the cyclicity of the disease (CY), the perceived disease's consequences (CQ), the perceived personal control on the disease (PC), the perceived control that the received treatment for the underlying condition is exerting on the disease (TC), the personal coherence of the disease (CH) and a scale that assesses the emotional response (ER). A higher score on the TI scale indicates more chronic perceived course of the disease; a higher score on the CY scale indicates the patient's capacity to predict a given course of the disease; a higher score on the CQ scale indicates the patient's belief that the disease has severe life consequences; a higher score on the PC scale indicates the patient's belief that he/she has an efficient control on his/hers own disease; a higher score on the CH scale indicates that the patient is understanding the underlying disease and a higher score on the ER scale indicates a more significant, perceived emotional impact of the disease.

Quality of Life Evaluation

The Short Form Health Survey Questionnaire (SF-36) was used for assessing physical and mental measures in the study population. The SF-36 comprises eight dimensions, and two general domains, the Physical Component Summary (PCS) and the Mental Component Summary (MCS). The domains of SF-36 have a score ranging from 0 to 100, a higher score (towards 100) indicating a better functioning for that respective domain. The eight evaluated domains of the SF-36 are the following: Physical Functioning: the lowest score defines limitation in performing all physical activities, including daily, personal

routine; Role-physical: the lowest score defines limitation in work or other activities as a result of physical impairment; Bodily Pain: the lowest score defines very severe and extremely limiting pain; General Health: the lowest score defines a personal health evaluation as being poor; Vitality: the lowest score defines tiredness all of the time; Social Functioning: the lowest score defines frequent, severe interference of the disease with normal social activities; Role-emotional: the lowest score defines problems with work and daily activities due to emotional disturbances; Mental Health: the lowest score defines constant feelings of nervousness and depression; Physical Component Summary: the lowest score defines limitations in self-care, social and role activities, severe bodily pain, frequent tiredness and a poor health-related evaluation; Mental Component Summary the lowest score defines frequent psychological distress, social and role disability due to emotional problems and a poor health-related evaluation.

Based on the two general scores, the PCS and the MCS, the included patients were further divided into three groups for each domain: the low-score PCS group (score between 0 and 49), the low-score MCS group (scores between 0 and 49), the medium-score PCS group (scores between 50 and 79), the medium-score MCS group (scores between 50 and 79) and the high-score PCS group (scores between 80 and 100) and the high-score MCS group (scores between 80 and 100), for the statistical analysis.

Statistical Analysis

All statistical analysis were performed using SPSS 20.0 statistical standard package for Mac OS X. Data were expressed as mean and standard deviation (SD) for continuous variables and as percentage with frequencies analysis for categorical variables. Bivariate correlation analysis, using Pearson's method was used for correlation between included variables. One-way analysis of variance ANOVA was used for categorical independent variables with more than two categories (the PCS type with three groups: low-scores, medium scores and high scores and the MCS type with three groups: low-scores, medium-scores and high-scores) and normally distributed interval dependent variables in order to test for differences in the means of the dependent variables, broken down by the levels of the independent variable. To evaluate the nature of the differences between the groups, a statistically significant ANOVA result was further followed by the Fisher's LSD post-hoc test. A statistically significant two-tailed p value of < 0.05 was considered.

Results and discussions

There was a total number of 122 patients included in the study. Baseline characteristics of the study population are summarized in Tables 1, 2, 3, 4, 5 and 6. Mean age was 56.84 ± 13.92 years, 72 patients (59%) were males and 70 patients (57.4%) lived in urban area. There were 47 patients (38.5%) that received hemodiafiltration (HDF) while the remaining 75 patients (61.5%) received conventional HD treatment; vascular access was represented, for 92 patients (75.4%) by an arteriovenous fistula (AVF) and, for 29 patients (23.8%) by a long-term catheter. The participants were receiving HD treatment for a mean of 72.97 ± 64.87 months, and the mean Kt/V was 1.33 ± 0.30 , suggesting an adequate HD treatment in the present cohort. Mean systolic blood pressure (SBP) was 148.89 ± 19.62 mmHg and mean diastolic blood pressure (DBP) was 77.01 ± 11.98 mmHg (table 1). The comorbidities in the study population and the chronic medication are described in tables 1 and 2.

Table 1
SOCIO-DEMOGRAPHIC, CLINICAL, HD-RELATED
PARAMETERS FOR THE STUDY POPULATION (N = 122)

CHARACTERISTICS	MEAN (\pm SD)
Age (years)	56.84 (13.92)
Gender (male, %)	72 (59%)
Living Environment (urban %)	70 (57.4%)
<u>Vascular Access:</u>	
Arteriovenous Fistula (N, %)	92 (75.4%)
Long-Term Catheter (N, %)	29 (23.8%)
Hemodialysis Type (HDF, %)	47 (38.5%)
Dialysis Vintage (months)	72.97 (64.87)
Kt/V	1.33 (0.30)
SBP (mmHg)	148.89 (19.62)
DBP (mmHg)	77.01 (11.98)
<u>RENAL DISEASE ETIOLOGY</u>	
Chronic Glomerulonephritis (N, %)	41 (33.6%)
Nephroangiosclerosis (N, %)	9 (7.4%)
Ischaemic Nephropathy (N, %)	7 (5.7%)
Diabetic Nephropathy (N, %)	26 (21.3%)
ADPKD (N, %)	13 (10.7%)
Obstructive Nephropathy (N, %)	5 (4.1%)
Tubulointerstitial Nephropathy (N, %)	16 (13.1%)
Lupus Nephropathy (N, %)	4 (3.3%)
<u>COMORBIDITIES</u>	
Essential HTN (N, %)	49 (40.2%)
Secondary HTN (N, %)	59 (48.4%)
<u>Cardiovascular Disease:</u>	
Chronic Ischemic Heart Disease (N, %)	31 (25.4%)
Chronic Atrial Fibrillation (N, %)	16 (13.1%)
Dilated Cardiomyopathy (N, %)	15 (13.3%)
Chronic Heart Failure (N, %)	17 (13.9%)
<u>Diabetes Mellitus:</u>	
Type 1 DM (N, %)	5 (4.1%)
Type 2 DM (N, %)	26 (21.3%)
Virus C Hepatitis (N, %)	26 (21.3%)
Secondary Anemia (N, %)	99 (81.1%)
Secondary Hyperparathyroidism (N, %)	50 (41%)

Mean Hb levels were 11.24 ± 1.32 g/dL, mean C reactive protein (CRP) levels were 18.41 ± 40.97 mg/L, mean albumin levels were 4.69 ± 0.61 g/dL, mean CT levels were 178.57 ± 44.29 mg/dL, mean HDL-CT levels were 42.06 ± 16.38 mg/dL, mean LDL-CT levels were 102.82 ± 36.66 , mean TG levels were 174.19 ± 110.79 mg/dL (table 3).

Table 4 summarizes BIS measurements. Mean LTM for the entire population was 35.47 ± 9.53 kg, mean FM was 27.57 ± 13.64 kg, mean ATM was 37.52 ± 18.54 kg, mean BMI was 27.18 ± 5.89 kg/m², mean LTI was 12.86 ± 2.77 kg/m² and mean FTI was 13.76 ± 6.72 kg/m².

The mean scores for R-IPQ and SF-36 evaluation are presented in Table 5 and 6, respectively. In general, the included cohort showed a decreased quality of life, expressed by a mean PCS score of 45.12 ± 23.69 and a mean MCS score of 55.47 ± 22.96 . Regarding illness perception examination, the lowest score was registered

Table 2
CHRONIC MEDICATION OF THE STUDY POPULATION (N = 122)

CHARACTERISTICS	MEAN (\pm SD)
<u>CHRONIC MEDICATION</u>	
Diuretics (N, %)	27 (22.1%)
ACEI, (N, %)	10 (8.2%)
ARB, (N, %)	2 (1.6%)
Beta-Blockers (N, %)	52 (42.6%)
Calcium Channel Blockers (N, %)	32 (26.2%)
Nitrates (N, %)	10 (8.2%)
Antiarrhythmics (N, %)	8 (6.6%)
Antiaggregants (N, %)	57 (46.7%)
Statins (N, %)	5 (4.1%)
ESAs (N, %)	94 (77%)
IV Iron (N, %)	95 (77.9%)
<u>Vitamin D Analogues:</u>	
Alpha D ₃ (N, %)	73 (59.8%)
Pancalcitol (N, %)	16 (13.1%)
Calcimimetics (N, %)	7 (5.7%)
<u>Phosphate Binders:</u>	
Sevelamer Carbonate (N, %)	8 (6.6%)
Calcium acetate/Mg carbonate (N, %)	21 (17.2%)

Table 3
LABORATORY MEASUREMENTS FOR THE STUDY
POPULATION (N = 122)

HEMATOLOGICAL & BIOCHEMICAL PARAMETERS	MEAN (\pm SD)
Hemoglobin (g/dl)	11.24 (1.32)
Hematocrit (%)	34.32 (4.09)
TSAT (%)	28.57 (14.41)
ALT (IU/l)	18 (12.12)
AP (IU/l)	105.68 (59.71)
Potassium (Eq/l)	5.05 (0.78)
Sodium (mEq/l)	137.55 (2.88)
Phosphorus (mg/dl)	4.54 (1.30)
PTH _i (ng/l)	610.00 (530.48)
Ca ²⁺ (mg/dl)	39.68 (11.84)
Total Serum Calcium (mg/dl)	8.73 (0.73)
Magnesium (mg/dl)	2.50 (0.34)
CRP (mg/l)	18.41 (40.97)
Albumin, Alb (g/dl)	4.69 (0.61)
Ferritin (ng/l)	781.15 (554.13)
CT (mg/dl)	178.57 (44.29)
HDL-CT (mg/dl)	42.06 (16.38)
LDL-CT (mg/dl)	102.82 (36.66)
TG (mg/dl)	174.19 (110.79)

by CY domain, with a mean value of 9.50 ± 1.90 , suggesting that the included patients can not accurately predict the illness' course, or possible arising complications. Decreased score for illness perception were also observed for the TC and CH domains, with a mean value of 13.85 ± 2.05 and 13.63 ± 3.38 , respectively, suggesting that the included patients do not understand their disease and do not consider that HD treatment is efficiently controlling the ESRD pathology.

The bivariate correlation analysis showed that PCS score was positively associated to the following parameters: K ($r = 0.191$; $p < 0.05$), PTH_i ($r = 0.187$; $p = 0.05$), albumin ($r = 0.191$; $p < 0.05$), HDL-CT ($r = 0.217$; $p < 0.05$), ICW ($r = 0.183$; $p < 0.05$), TBW ($r = 0.183$; $p < 0.05$), BCM ($r = 0.225$; $p < 0.05$), LTM ($r = 0.236$; $p < 0.05$), LTI ($r = 0.185$; $p < 0.05$), LTM/W ($r = 0.255$; $p < 0.05$), TC ($r = 0.283$; $p < 0.05$), CH ($r = 0.54$; $p < 0.01$) and was inversely associated to the following parameters: age ($r = -0.390$; $p < 0.01$), PLT ($r = -0.258$; $p < 0.05$), albumin ($r = -0.191$; $p < 0.05$), CT ($r = -0.200$; $p < 0.05$), TG ($r = -0.190$; $p < 0.05$), ECW/ICW ($r = -0.200$; $p < 0.05$).

Table 4
BODY COMPOSITION MONITOR MEASUREMENTS FOR THE STUDY POPULATION (N = 122)

BIOIMPEDANCE PARAMETERS	MEAN (\pm SD)
Measured Overhydration, OH (l)	1.30 (1.47)
Relative Overhydration, OH/ECW (%)	7.37 (8.25)
Extracellular Water, ECW (l)	18.50 (19.53)
Intracellular Water, ICW (l)	18.26 (4.62)
ECW to ICW Ratio, ECW/ICW	0.94 (0.12)
Total Body Water, TBW (l)	34.95 (7.22)
Lean Tissue Mass, LTM (Kg)	35.47 (9.53)
Adipose Tissue Mass, ATM (Kg)	37.52 (18.54)
Fat Mass, FM (Kg)	27.57 (13.64)
Body Cell Mass, BCM (Kg)	19.33 (6.32)
Body Mass Index, BMI (Kg/m ²)	27.18 (5.89)
Lean Tissue Index, LTI (Kg/m ²)	12.86 (2.77)
Fat Tissue Index, FTI (Kg/m ²)	13.76 (6.72)
LTM to Weight Ratio, LTM/Wgt (%)	48.36 (15.55)
ATM to Weight Ratio, ATM/Wgt (%)	35.31 (11.66)

Table 5
MEAN SCORES FOR THE R-IPQ FOR THE STUDY POPULATION (N = 122)

REVISED ILLNESS PERCEPTION QUESTIONNAIRE (R-IPQ) DOMAINS	MEAN (\pm SD)
Timeline Acute/Chronic, TI	20.60 (3.44)
Timeline Cyclical, CY	9.50 (1.90)
Consequences, CQ	16.43 (2.70)
Personal Control, PC	14.10 (1.92)
Treatment Control, TC	13.85 (2.05)
Illness Coherence, CH	13.63 (3.38)
Emotional Response, ER	14.78 (4.64)

0.220; p < 0.05), BMI (r = -0.181; p < 0.05), FTI (r = -0.180; p < 0.05), ATM/W (r = -0.241; p < 0.05), CQ (r = -0.664; p = 0.01), CY (r = -0.363; p < 0.01), ER (r = -0.540; p < 0.01).

The bivariate correlation analysis for MCS score showed a statistically significant positive correlation to the following parameters: PTH_i (r = 0.189; p < 0.05), OH (r = 0.193; p < 0.05), TC (r = 0.298; p < 0.01), CH (r = 0.576; p < 0.05) and a negative correlation to the following parameters: age (r = -0.198; p < 0.01), CT (r = -0.200; p < 0.05), TG (r = -0.198; p < 0.01), FTI (r = -0.208; p < 0.05); CQ (r = -0.687; p < 0.01), CY (r = -0.371; p < 0.01); ER (r = -0.650; p < 0.01).

Correlations of socio-demographics, hematological, biochemical, BIS and R-IPQ parameters between the three PCS groups (low-score, medium-score and high-score)

The independent between-groups ANOVA yielded a statistically significant effect for: age (F(2,119) = 8.53; p < 0.01); HDL-CT (F(2,119) = 3.38; p < 0.05), TI (F(2,119) = 4.59; p < 0.05), CQ (F(2,119) = 35.84; p < 0.01); TC (F(2,119) = 3.23; p < 0.05), CH (F(2,119) = 19.08; p < 0.01); CY (F(2,119) = 8.65; p < 0.01); ER (F(2,119) = 19.31; p < 0.01) (table 7).

The post-hoc test showed the following: the differences between the low-score PCS group and the high-score PCS group were statistically significant for: age (t(119) = 13.35; p = 0.00), HDL-CT (t(119) = -11.13; p = 0.01), TI (t(119) = 2.34; p = 0.01), CQ (t(119) = 4.68; p = 0.00), TC (t(119) = -1.25; p = 0.02), CH (t(119) = -4.22; p = 0.00), CY (t(119) = 2.06; p = 0.00), ER (t(119) = 5.29; p = 0.00). The differences between low-score PCS group and the medium-score PCS group were statistically significant for: age (t(119) = 7.41; p = 0.00), CQ (t(119) = 2.21; p = 0.00), CH (t(119) = -2.81; p = 0.00), ER (t(119) = 4.32; p = 0.00). The differences between the medium-score PCS group and the high-score PCS group were statistically

Table 6
SF-36 MEAN SCORES FOR THE STUDY POPULATION (N = 122)

QUALITY OF LIFE (SF-36) DOMAINS	MEAN (\pm SD)
Physical Functioning	48.32 (28.67)
Role-Physical	39.75 (41.50)
Bodily Pain	50.27 (31.34)
General Health	38.70 (24.10)
Vitality	48.85 (23.25)
Social Functioning	63.90 (31.48)
Role-Emotional	59.03 (41.32)
Mental Health	66.25 (21.63)
Physical Component Score, PCS	45.12 (23.69)
Mental Component Score, MCS	55.47 (22.96)

Table 7
ONE-WAY ANOVA SUMMARY FOR THE PCS GROUPS

DEPENDENT VARIABLE	df	F	p
Age (years)	2	8.53	<0.01
Between			
Within	119		
HDL-CT (mg/dl)	2	3.38	<0.05
Between			
Within	119		
TI	2	4.59	<0.05
Between			
Within	119		
CQ	2	35.84	<0.01
Between			
Within	119		
TC	2	3.23	<0.05
Between			
Within	119		
CH	2	19.08	<0.01
Between			
Within	119		
CY	2	8.65	<0.01
Between			
Within	119		
ER	2	19.31	<0.01
Between			
Within	119		

significant for: TI (t(119) = 3.06; p = 0.00), CQ (t(119) = 2.46; p = 0.00), CY (t(119) = 1.65; p = 0.00).

Correlations of socio-demographics, hematological, biochemical, BIS and R-IPQ parameters between the three MCS groups (low-score, medium-score and high-score)

The independent between-groups ANOVA yielded a statistically significant effect for: age (F(2,119) = 4.80; p < 0.05); PTH_i (F(2,119) = 3.26; p < 0.05); CT (F(2,119) = 4.12; p < 0.05); TG (F(2,119) = 3.29; p < 0.05); OH (F(2,119) = 4.32; p < 0.05); OH/ECW (F(2,119) = 3.41; p < 0.05); FTI (F(2,119) = 3.89; p < 0.05); TAS (F(2,119) = 5.96; p < 0.05); TAD (F(2,119) = 3.19; p < 0.05); CQ (F(2,119) = 38.41; p < 0.01); TC (F(2,119) = 6.08; p < 0.05); CH (F(2,119) = 22.10; p < 0.01); CY (F(2,119) = 7.23; p < 0.01); ER (F(2,119) = 32.15; p < 0.01) (table 8).

The post-hoc test showed the following: the differences between the low-score MCS group and the high-score MCS group were statistically significant for: age (t(119) = 10.69; p = 0.00), PTH_i (t(119) = -330.22; p = 0.01), CT (t(119) = 22.83; p = 0.04), FTI (t(119) = 3.66; p = 0.03), TAS (t(119) = 14.69; p = 0.03), CQ (t(119) = 4.63; p = 0.00), TC (t(119) = -1.63; p = 0.03), CH (t(119) = -4.81; p = 0.00), CY (t(119) = 1.75; p = 0.00), ER (t(119) = 7.10; p = 0.00). The differences between the low-score MCS group and the

Table 8
ONE-WAY ANOVA SUMMARY FOR THE MCS GROUPS

DEPENDENT VARIABLE	df	F	P
Age (years)			
Between	2	4.80	<0.05
Within	119		
PTH _i (ng/l)			
Between	2	3.26	<0.05
Within	119		
CT (mg/dl)			
Between	2	4.12	<0.05
Within	119		
TG (mg/dl)			
Between	2	3.29	<0.05
Within	119		
OH (l)			
Between	2	4.32	<0.05
Within	119		
OH/ECW (%)			
Between	2	3.41	<0.05
Within	119		
FTI (kg/m ²)			
Between	2	3.89	<0.05
Within	119		
TAS (mmHg)			
Between	2	5.96	<0.05
Within	119		
TAD (mmHg)			
Between	2	3.19	<0.05
Within	119		
CQ			
Between	2	38.41	<0.01
Within	119		
TC			
Between	2	6.08	<0.05
Within	119		
CH			
Between	2	22.10	<0.01
Within	119		
CY			
Between	2	7.23	<0.05
Within	119		
ER			
Between	2	32.15	<0.01
Within	119		

medium-score MCS group were statistically significant for: CT ($t(119) = 22.95$; $p = 0.00$), TG ($t(119) = 52.16$; $p = 0.01$), OH ($t(119) = -0.84$; $p = 0.00$), OH/ECW ($t(119) = -4.20$; $p = 0.01$), FTI ($t(119) = 3.24$; $p = 0.01$), CQ ($t(119) = 2.30$; $p = 0.00$), TC ($t(119) = -0.99$; $p = 0.01$), CY ($t(119) = 0.73$; $p = 0.04$), ER ($t(119) = 4.44$; $p = 0.00$). Finally, the differences between the medium-score MCS group and the high-score MCS group were statistically significant for: PTH_i ($t(119) = -290.29$; $p = 0.03$), TAS ($t(119) = 15.85$ $p = 0.01$), TAD ($t(119) = 7.59$; $p = 0.01$), CQ ($t(119) = 2.33$; $p = 0.00$), CH ($t(119) = -2.45$; $p = 0.01$), CY ($t(119) = 1.02$; $p = 0.02$), ER ($t(119) = 2.65$; $p = 0.00$).

There are several reports that associate undernutrition in HD population with several nutritional and inflammatory markers, as decreased concentration of serum albumin, decreased concentration of serum cholesterol, low levels of BMI and elevated serum concentration of CRP [10,16]. Furthermore, malnutrition is an independent risk factor for morbidity and mortality in ESRD patients [8,9]. Impaired QoL in these patients has a multifactorial origin, the baseline renal disease, the renal replacement therapy itself, the increased number of comorbidities, the systemic chronic inflammation and fluid overload status and the PEW

syndrome being all accountable for a significantly decreased level of social, familial and professional interaction for ESRD patients receiving HD treatment [9,10,12,17]. In the last years, nutritional parameters evaluated through bioimpedance spectroscopy analysis, have gained a well-deserved place among the principal, fastest, easiest and reproducible techniques of accurate nutrition assessment [14,18-26]. Low muscle mass, expressed either as LTM (kg) or LTI (kg/m²), a BIS-derived parameter, was found to be associated with higher mortality in HD patients [12,13,17]. In 2010, Huang et al. conducted a study on 1709 patients from the Hemodialysis Study, in order to evaluate the relationship between body composition and all-cause mortality and found that low muscle mass and low fat mass are predictors for all-cause mortality [12]. A recent 2018 study, performed on 48 HD patients showed that lower LTI ($p = 0.013$) and higher hsCRP levels ($p = 0.011$) were associated with higher mortality in the study's cohort [13].

Our study, performed in 122 stable HD patients, showed result consistent with previous studies findings. In the present study, there was a statistically significant correlation between decreased illness perception and QoL scores and malnutrition and BIS-derived parameters. Therefore, the present analysis showed that the 122 included patients perceived an impaired illness perception and quality of life. The mean PCS score was negatively associated with a low serum albumin concentration, low serum total cholesterol and triglycerides concentration, low BMI, FTI and ATM/W levels, suggesting that undernutrition, expressed as low levels of nutritional markers, are associated to decreased quality of life in these patients, in terms of SF-36 physical domains evaluation. Also, mean MCS score was negatively associated with low serum total cholesterol and triglycerides concentration and with low FTI levels, suggesting a correlation between undernutrition and impaired quality of life, in terms of SF-36 mental assessment. In the same manner, the present study showed an association between nutritional markers and illness perception, and between R-IPQ scores and QoL scores, the two psychometric evaluation scales revealing consistent results.

The strengths of the present study consist in the multifactorial approach, analyzing socio-demographical, clinical, hematological, biochemical and BIS-derived parameters in relationship with two major psychometric evaluation scales. The limitation of the study are represented by the observational, cross-sectional design of the study that can not establish a causal relationship, and the relatively small sample size.

Conclusions

Well-conducted, large sample size cohort and randomized controlled trials are needed in order to establish a direct, strong, causality relationship between malnutrition-inflammation markers, BIS-derived parameters, QoL and mortality in HD patients, in order for efficient behavioral therapies to be part of a constant, long-term therapeutically approach in these patients.

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