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Functional Class Deterioration Associated with Changes in Body Weight, Muscle Strength and Body Water in Chronic Stable Heart Failure Patients

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Abstract

Background: Over the course of heart failure, clinical manifestations can be explained by changes in body composition, mainly as decrease in body weight and lean body mass and body water imbalance. The aim of this study was to examine the association of changes in weight, handgrip strength and total body water with clinical status in patients with chronic stable heart failure.

Methods: In a longitudinal cohort prospective study 222 consecutive patients (55.6% men, median age 67 years) were included. They underwent measurements at the beginning and after 6 months. Weight, height, hip circumference, waist circumference, handgrip strength, total body water and extracellular water (using Bioelectrical Impedance) were evaluated.

Results: Three different types of change combinations were more frequently observed in patients with functional class deterioration: a) weight loss, increase in total body water and extracellular water and decreased handgrip strength (p=0.049), b) increased weight, total body water and extracellular water and decreased handgrip strength (p=0.01) and c) unchanged weight, decreased total body water and extracellular water and decreased handgrip strength (p=0.01).

Conclusions: Handgrip strength, total body water and extracellular water were better predictors of clinical deterioration than weight alone as indicators of functional class deterioration and should be evaluated in heart failure patients.

Keywords: Weight change; Handgrip strength; Total body water; Functional class deterioration; Heart failure

Introduction

Heart Failure (HF) is a multisystem disorder characterized by structural and functional cardiac, skeletal muscle and renal abnormalities, mainly with symptoms and signs of fluid retention, dyspnea and fatigue [1]. Manifestations of skeletal muscle loss are decreased hand strength, loss of respiratory muscle strength and increased fatigue [2].

Accurate evaluation of functional class deterioration in heart failure can be difficult (3), because it requires objective measurements to aid early diagnosis in patients in whom symptoms may be non-specific and physical abnormalities are not evident during examination [3].

Due to these limitations, it is important to have an objective method to measure body composition and fluid changes in HF patients. Bioelectrical Impedance (BEI) is a very practical tool, as it is noninvasive, inexpensive, simple to implement, reproducible, and sensitive to changes in body composition [4]. Also, it is able to detect altered electric properties in the tissue of ill subjects, and this may be more predictive of worse prognosis than the weight loss.

In a previous cross-sectional study we demonstrated the cross-inverse correlation between the fluid overload estimated with bioelectrical impedance analysis (BIA) and New York Heart Association functional class [5]. Paterna et al. used BIA safely in monitoring hospitalized patients with refractory congestive HF treated with high-dose intravenous furosemide and hypertonic saline solutions [6]. This tool has also been validated in identifying HF as a cause of acute dyspnea in emergency room; demonstrating a cross-inverse correlation of BIA measurements with B-type natriuretic peptide levels [7]. However, almost all papers involved hospitalized patients and not those with stable, chronic heart failure.

The objective of this longitudinal study was to determine whether changes in body weight, muscle strength and bioimpedance measurements were related to functional class deterioration.

Material and Methods

Patients

A total of 222 (123 male and 99 female) stable out patients consecutively enrolled in the Heart Failure Clinic at the Instituto Nacional de Ciencias Médicas y Nutricion "Salvador Zubirán" (INCMNSZ), were considered eligible if they were over 18 years old, with a confirmed diagnosis of HF based on European Society of Cardiology criteria. Clinical status was measured with NYHA (New York Heart Association) functional classification. Patients in NYHA I-III were accepted.

Exclusion criteria were: advanced renal disease, active neoplastic process, physical disability, decompensated heart failure, AIDS,

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rheumatoid arthritis and participation in other clinical trials. The present study was approved by the institutional ethics committee of biomedical research in humans of the INCMNSZ, and all patients were informed regarding the purpose of the study and signed informed consent forms.

The follow-up period was 6 months. Patients underwent measurements twice. Each time weight, height, hip and waist circumferences were assessed; handgrip strength was measured using Takei Hand Dynamometer (0-100 kg). Patients were instructed to apply as much handgrip pressure as possible with their dominant hand three times, and the mean of the scores was recorded in kilograms.

Anthropometry and handgrip strength

Weight and height were measured in accordance with the reference manual of anthropometric standardization. All subjects wore light clothing and were barefoot. Body Mass Index (BMI), was calculated by dividing total body weight (Kilograms) to the height squared (square meters). Waist and hip circumferences were also measured, as well as hand-grip strength using the Smedley Hand Dynamometer (Stoelting, Wood Dale K).

Bioelectrical impedance analysis

Whole-body bioelectrical impedance was measured by using tetrapolar and multiple frequencies equipment (BodyStat QuadScan 4000, BODYSTAT LTD; Isle of Man, British Isles). Volumes of body fluid compartments were estimated using a modeling program supplied by the manufacturer of the analyzer with a 200 kHz signal to assess total body water (TBW) and a 5 kHz signal to assess extracellular water (ECW). An independent panel of BIA experts in 1997 recommended the utilization of multi-frequency BIA in estimating TBW, ECW, and intracellular water (ICW=TBW-ECW) to determine altered fluid distribution [8]. Total body water and extracellular body water (BIVA, Body Stat Quad Scan 4000) in each measurement were calculated.

Clinical data

Clinical data like dyspnea, fatigue, decubitus intolerance, NYHA functional class, cardiac rate and blood pressure were evaluated during the medical interview by a cardiologist who was blinded to the body composition evaluation. Body weight, handgrip strength and total and extracellular water (loss and gain changes) were defined as loss or gain>or<5% over 6 months period.

Statistical analysis

Analyses were performed using a commercially available package (SPSS for Windows, Version 17) and the BIVA Software 2002. Continuous variables were expressed as mean ± standard deviation (SD) or as median (25 by 75 percentiles), and categorical variables were presented as absolute and relative frequencies.

The groups of patients with deterioration of clinical status were compared to those without deterioration with Pearson´s chi-square for categorical variables and an unpaired t-test for continuous variables. Independent risk factors of functional class deterioration were identified by a logistic regression analysis. A p value<0.05 was considered statistically significant.

Results

We identified 49 (22.1%) patients whose functional class deteriorated during the follow-up. From the total population, 123 (55.4%) were men with a median age of 67 (53-75) years (Table 1).

The patients were classified in two groups: with and without deterioration, according to the (NYHA) functional capacity. Table 2 shows that the highest percentage of change observed was associated with deterioration in the Reactance/Height ratio as an important decrease (p=0.017).

The main changes in body composition are shown in Figure 1, and we can observe that as the number of subjects with functional class deterioration increased, TBW (p=0.035) and ECW (p=0.048) increased and handgrip strength (p=0.017) decreased.

Combinations of changes in body composition were grouped in order to create patterns that would be useful in clinical practice to identify patient with functional class deterioration. And three different types of change combinations were more frequently observed in patients with functional class deterioration: a) weight loss, increase in total body water and extracellular water and decreased handgrip

Variables	n=222
Age, years	67 (53-75)
Men, n (%)	123 (55.4)
Women, n (%)	99 (44.6)
Height, (m)	1.58 ± 0.09
Comorbidities Obesity, n (%) Dyslipidemia, n (%) Diabetes, n (%) Hypertension, n (%)	 54 (24.3) 65 (29.3) 106 (47.7) 154 (69.4)
Heart rate (bpm)	70 (66-76)
Systolic blood pressure (mm Hg)	120 (110-138.75)
Diastolic blood pressure (mm Hg)	70 (70-80)
Diastolic dysfunction, n (%)	47 (21.2)
Systolic dysfunction, n (%)	89 (40.1)
Systolic and diastolic dysfunction, n (%)	65 (29.3)
Right ventricular dysfunction, n (%)	64 (28.8)
New York Heart Association classification I, n (%) II, n (%) III, n (%)	 133 (61.9) 71 (33) 11 (5.1)
Symptoms Dyspnea Fatigue	 98 (43.9) 132 (59.2)

Data expressed as mean ± standard deviation, median (interquartile range) or numbers (percentage) when appropriate.

Table 1: General basal characteristics of heart failure patients.

Variables	Change (%)		*p*
	Deterioration N=49	**No deterioration N=173**	
Weight (kg)	0 (-3.4-2.6)	0.15 (-2.4-2.4)	0.769
Handgrip strength (kg)	0 (-11.4-9.0)	0 (-8.3-13.5)	0.375
TBW (liters)	0.48 (-4.1-6.3)	0.24 (-2.9-3.8)	0.537
ECW (liters)	1.74 (-6 .7-13.6)	0.90 (-4.8-5.7)	0.162
BMI (kg/m^2)	0 (-3.4-2.6)	0.15 (-2.4-2.4)	0.769
C. Waist (cm)	0.43 (-3.6-3.3)	0.81(-2.8-3.9)	0.725
C. Hip (cm)	-0.1 (-2.7-3.3)	0.18 (-2.5-2.7)	0.933
C.arm (cm)	-2.07 (-5.5-6.3)	1.42 (-4.0-5.3)	0.357
Resistence/Height (ohm/m)	-1.36 (-10.9-4.7)	-1.46 (-6.4-5.6)	0.393
Reactance/Height (ohm/m)	**-5.9 (-27.6-7.7)**	**-0.59 (-9.2-9.2)**	**0.017**
Impedance Index	1.2 (-0.2-2.4)	1.19 (-1.3-1.3)	0.206
Caloric intake (Kcal)	-14.08 (-24-15.1)	0.58 (-29.9-43.5)	0.446

TBW: Total Body Water; ECW: Extracellular Water; BMI: Body Mass Index; C: Circumference; Data expressed as median (interquartile range).

Table 2: Percentage of change between groups with and without Deterioration.

strength (p=0.049), b) increased weight, total body water and extracellular water and decreased handgrip strength (p=0.01) and c) unchanged weight, decreased total body water and extracellular water and decreased handgrip strength (p=0.01) (Figure 2).

Finally, in the logistic regression the body composition changes that were independently associated with functional class deterioration were increase in ECW>5% and decrease in handgrip strength>5%. (Table 3)

Discussion

In the present study the functional class deterioration was present in 22.1% of the patients and was associated with the use of diuretics, the presence of dyslipidemia and systolic and diastolic dysfunction, an increase>5% of extracellular water and a decrease>5% of handgrip strength.

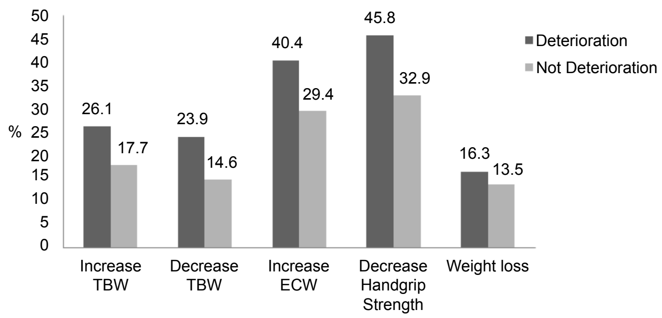

Figure 1: Changes in body composition according to deterioration or not deterioration of NYHA functional class.

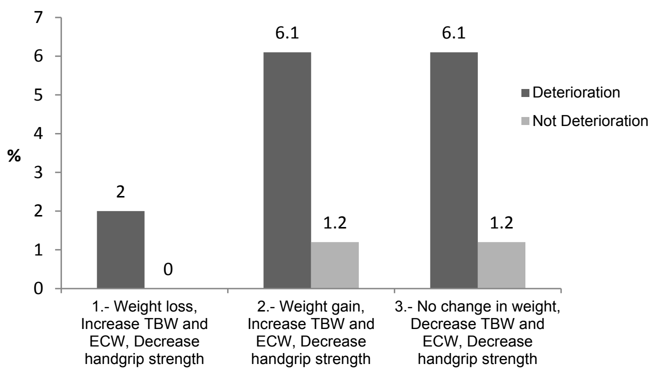

Figure 2: Combinations of changes in body composition according to deterioration or not deterioration of NYHA functional class.

Variables	Exp (β)	CI 95%	β	*p*
Diuretics (yes/no)	2.04	(1.16–3.59)	0.71	**0.014**
Dyslipidemia (yes/no)	1.84	(1.06–3.20)	0.61	**0.031**
Increase in ECW (>5%)	2.00	(1.15–3.48)	0.69	**0.014**
Decrease in handgrip strength (>5%)	2.16	(1.27–3.68)	0.77	**0.005**
Diastolic dysfunction (yes/no)	2.16	(1.07–4.38)	0.77	**0.032**
Systolic and diastolic dysfunction (yes/no)	4.29	(2.3–8.01)	1.46	**<0.001**

ECW: Extracellular water

Table 3: Logistic Regression to determinate factors associated with deterioration of NYHA.

The Taekema D study, which used handgrip strength as a predictor of functional health, social and psychological status, found that loss of force was associated with deteriorating health in these three areas. In the present study, there were a higher proportion of patients with decreased muscle strength in the deterioration group, while muscle strength was increased more frequently in the group without deterioration regardless of the type of ventricular dysfunction.

A greater proportion of patients with deterioration also had higher extracellular water compared with the group without deterioration. A weight increase or decrease of 5.4 kg is most probably explained by fluid expansion that may not be clinically identifiable due to the negative pressure in soft tissue, so it may occur in presence of severe dehydration without clinical edema. Thus, the assessment of total body and extracellular water using bioelectrical impedance is useful for identifying this volume retention, even before edema can be identified. In the Sergi study of body water distribution in older adults with heart failure only extracellular water was found to predict the status of fluid retention [9].

A Cotter G, et al. review analyzed the results of two studies comparing groups of patients initially diagnosed with chronic HF [10]. One group consisted of patients who suffered an acute event superimposed on chronic HF with another in which did not have acute events. Weight gain was not statistically different between groups. The increase was about 2 kg, suggesting that volume overload in acute HF mainly occurs as pulmonary congestion and is due to the redistribution of the fluids, and not necessarily to greater retention.

In patients with HF there is often a displacement of body water to the interstitial (third) space, for example in the case of pulmonary edema, without changes in body weight. This can mask the loss of chemical and cellular components. Moreover, the depletion of protein reserves increases the volume of extracellular water and makes the evaluation of free fat mass difficult [11]. In addition, without an assessment of fluid variations treatment with diuretics may not be indicated until it is restored to the intravascular space. Bioelectric impedance analysis is the most sensitive and useful method for evaluation in the clinical setting. These results demonstrate the need for study of the body compartments. Since subjective measurements cannot distinguish compartmentalization of fluids BIA is the technique of choice.

The present study has some limitations given the relatively small sample size of selected patients and the fact that it was a prospective and single-center study. These factors may limit the ability to generalize the results observed in this study. However, our findings are particularly encouraging, and they should serve as a basis for future research, including larger samples, aimed at enhancing the management of heart failure patients.

Handgrip strength, total body water and extracellular water were better predictors of functional class deterioration than weight alone. Therefore we propose the routinely evaluation of extracellular water and handgrip strength in heart failure patients to improve therapeutic strategies and the prognosis of heart failure patients.

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