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ORIGINAL ARTICLE

# Body composition analysis in chronic dialysis patients: a longitudinal study

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## Abstract

*Objective: Nutritional status is an important determinant of morbidity and mortality in dialysis patients. Body composition analysis bioelectrical impedance techniques are becoming commonplace in the clinical setting. Our objective is to report our clinical experience using bioelectrical impedance analysis for the prospective nutritional surveillance of dialysis patients.*

*Methods: A total of 204 patients, 157 on hemodialysis and 47 on peritoneal dialysis were followed for a median of 21 months. Values from the first trimester were averaged and compared to those obtained in the last trimester. Bioelectrical impedance values were obtained using a single frequency (50 kHz) bioimpedance analyzer.*

*Results: Baseline values for body weight, height, body mass index and body surface area were similar in both treatment modalities. Hemodialysis patients lost a discreet amount of body weight (1.5%, p=0.0334). Body weight did not change in peritoneal dialysis patients. Significant decreases in resistance (p=0.l0023) and phase angle (p=0.0481) were noted in hemodialysis but not peritoneal dialysis patients. A small but significant decrease in fat free (1.8%; p=0.0028) and body cell free (3.3%; p=0.0036) mass was noted in hemodialysis but not peritoneal dialysis patients.*

*Conclusions: 1. Bioelectrical impedance analysis may detect losses in fat free mass and body cell mass that are not apparent by body weight monitoring. 2. Bioelectrical impedance analysis is a practical clinical tool for evaluating body composition in dialysis patients.*

*Key words: Bioelectrical impedance, Body composition, Dialysis, Nutrition*

## 中文摘要

目的：營養狀況是決定透析患者致殘率和死亡率的重要因素。人體組成分析生物電阻抗技術在臨床上的應用日益普及。本文旨在報道在我們的臨床經驗中，使用生物電阻抗分析來前瞻性地監測透析患者的營養狀況。

方法：對204例患者（157例正在接受血液透析，47例正在接受腹膜透析）進行了21個月（中位數）的隨訪。計算首三個月和最後三個月的均值，並對兩者進行比較。通過單頻（50 kHz）生物阻抗分析儀對生物電阻抗值進行了測量。

結果：在兩個治療模型中，體重、身高、體重指數、和體表面積的基線值相似。接受血液透析的患者體重略有下降(1.5%；*p*=0.0334)，但在腹膜透析的患者中體重沒有變化。在血液透析患者中電阻（*p*=0.l0023）和相位角（*p*=0.0481）的下降顯著，但在腹膜透析患者中則不明顯。在血液透析患者中觀察到有

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少量的但顯著的去脂肪體重（1.8%；$p$=0.0028）和去體細胞體重（3.3%；$p$=0.0036）的下降，但在腹膜透析患者中則未觀察到。

結論：1. 生物電阻抗分析可檢測去脂肪體重和體細胞體重的丟失，而這種丟失通過體重監測很難測出來。2. 生物電阻抗分析可在臨床上應用作為評估透析患者人體組成的工具。

## INTRODUCTION

Nutritional status is an important determinant of morbidity and mortality in dialysis patients (1-6). The underlying causes of malnutrition are multiple, but recent attention has focused on decreased caloric and protein intake, chronic inflammation and concurrent chronic conditions such as diabetes mellitus and congestive heart failure (9-17). Unlike hemodialysis patients in whom protein malnutrition and weight loss may predominate, peritoneal dialysis patients often gain body weight and fat mass that may mask actual loss of muscle mass.

Nutritional status is clinically evaluated by subjective global assessment, anthropometry including skin-fold measurements, or by means of quantitative biochemical parameters such as albumin and transferrin concentrations. Densitometric measurements of body density (fat content) and deuterium-isotope dilution measurements of total body water are impractical for surveillance of large patient populations. Noninvasive techniques, such as dual energy x-ray absorptiometry and bioelectrical impedance analysis are becoming commonplace in the clinical setting. The latter is simple, reproducible, easy to use and transportable making it attractive in the routine clinical setting (28,32-35). The bioimpedance parameters resistance, reactance and phase angle correlate closely with total body water, intracellular water, body cell mass, and fat free mass.

The objective of this study is to report our clinical experience using bioelectrical impedance analysis in the prospective nutritional surveillance of dialysis patients.

## PATIENT AND METHODS

A total of 204 patients (median duration on dialysis therapy was 12 months) were followed for a median of 19 months. Values from the first trimester were averaged and compared to those obtained in the last trimester. The treatment modality was hemodialysis in 157 (77%) and peritoneal dialysis in 47 (23%) patients.

Bioelectrical impedance values were obtained using a single frequency (50 kHz) bioimpedance analyzer. Studies were done at 15 minutes post hemodialysis or during a dry period in peritoneal dialysis patients. All patients were evaluated while sitting up in a hemodialysis chair. Care was taken to ensure that arms and hands were not touching the torso and that thighs were not in contact with each other. Disposable tetrapolar electrodes were placed over the bony aspect of the wrist and the ipsilateral ankle. The coefficient of variation for the impedance measurements with this technique is 0.5%, and the interoperator variability 1%. In hemodialysis patients the non-access side was used for placement of electrodes. Calculations were made using a parallel impedance model provided by the manufacturer (Cyprus 1.2 program, RJL Systems, Clinton Township, MI, US).

Bioelectrical impedance vector analysis was carried out as previously described and compared to data obtained as part of the National Health and Nutrition Examination Survey III (31).

Biochemical data was obtained monthly pre hemodialysis or during a peritoneal dialysis clinic visit, and the average parameter value for the entire period of observation used for analysis.

Results are expressed as mean ± standard deviation and as percentages where appropriate. Statistical comparisons were made using unpaired and paired T tests.

## RESULTS

Demographic characteristics of the study population are shown in Table 1. Peritoneal dialysis patients were younger than those on hemodialysis (50 ± 13 vs. 62 ±15 years; $p$<0.0001). Sex and race distributions were similar in both treatment modalities.

Morphometric parameters are shown in Table 2. Baseline values for body weight, height, body mass index, and body surface area were similar in both treatment modalities. Hemodialysis patients lost a discreet (1.5%) but significant amount of body weight ($p$=0.0334). Body weight did not change in peritoneal dialysis patients.

Bioelectrical impedance parameters are shown in Table 3. Initial parameter values were similar in hemodialysis and peritoneal dialysis patients. However, at the end of the observation period significant decreases in both resistance ($p$=0.0023) and phase angle ($p$=0.0481) were noted in hemodialysis but not peritoneal dialysis patients. These results are consistent with a decrease in intracellular water content in hemodialysis patients.

**Table 1.** Patient Demographics and mean laboratory parameters.

| | Hemodialysis | Peritoneal dialysis | *p* value |
|---|---|---|---|
| Number | 157 (77%) | 47 (23%) | |
| Age, years | 62 ± 15 | 50 ± 13 | <0.0001 |
| Sex | | | |
| Female | 40% | 38% | |
| Male | 60% | 62% | |
| Race | | | |
| Black | 34% | 26% | |
| White | 66% | 74% | |
| Duration of follow up, months | 21 ± 13 | 22 ± 13 | NS |
| Blood urea nitrogen, mmol/L | 7.50 ± 2.14 | 6.78 ± 2.50 | NS |
| S. creatinine, mmol/L | 831 ± 274 | 884 ± 380 | NS |
| S. calcium, mmol/L | 2.35 ± 0.23 | 2.35 ± 0.30 | NS |
| S. phosphorus, mmol/L | 1.78 ± 0.52 | 1.74 ± 0.48 | NS |
| S. albumin, g/L | 39 ± 4 | 36 ± 6 | <0.002 |
| S. hemoglobin, µmol/L | 7.32 ± 0.93 | 7.26 ± 1.18 | NS |

A direct linear correlation between body mass index and body fat% ($R$=0.650; $p$<0.0001) and an inverse correlation between body mass index and fat free mass% ($R$=0.651; $p$<0.0001) was noted. Derived parameters of body composition analysis are shown in Table 2. No differences in body composition parameters were noted between hemodialysis and peritoneal dialysis patients at the start of the surveillance period. During the observation period a small but significant decrease in fat free (1.8%; $p$=0.0028) and body cell mass (3.3%; $p$=0.0036) was noted in hemodialysis but not peritoneal dialysis patients. Bioelectrical impedance vector analysis data adjusted for sex and race is shown in Figure 1. The vectors for the study population of hemodialysis and peritoneal dialysis patients fall significantly to the right of the normal population vector (NHANES) indicating a state of overhydration in dialysis patients. No differences are observed between the hemodialysis and peritoneal dialysis vectors indicating a similar degree of overhydration. Biochemical parameters by treatment modality are shown in Table 1 as mean values for the entire observation period. Peritoneal dialysis patients had lower serum albumin values when compared to their hemodialysis counterparts ($p$<0.002). A direct linear correlation was found between the bioimpedance parameters reactance ($R$=0.305; $p$<0.0001) and phase angle ($R$=0.344; $p$<0.0001) and serum albumin concentration.

## DISCUSSION

This study demonstrates that bioelectrical impedance analysis can be routinely used in the clinical setting for the surveillance of nutritional status in dialysis patients. The technique is simple, portable, reproducible, easy to use, and requires no more than ten minutes of patient and staff time. In our center the primary responsibility for measurements rests with the renal dietitians, and is considered an integral part of their clinical patient evaluation.

Our findings also indicate that bioelectrical impedance analysis may detect losses in fat free mass and body cell

**Table 2.** Morphometric and body composition parameters.

| | Hemodialysis | | Peritoneal dialysis | |
|---|---|---|---|---|
| | Initial | Final | Initial | Final |
| Weight, kg | 74.6 ± 18.8 | 73.7 ± 18.0 | 74.9 ± 15.6 | 78.0 ± 17.6 |
| Height, cm | 169 ± 10 | 169 ± 10 | 170 ± 11 | 170 ± 11 |
| Body mass index, kg/m$^2$ | 26.1 ± 6.1 | 25.7 ± 6.0* | 25.8 ± 4.6 | 26.6 ± 4.8 |
| BSA, m$^2$ | 1.84 ± 0.24 | 1.83 ± 0.23 | 1.86 ± 0.22 | 1.89 ± 0.24 |
| Fat free mass, kg | 55.0 ± 13.6 | 54.0 ± 13.5† | 56.2 ± 12.9 | 57.6 ± 14.8 |
| Body cell mass, kg | 23.7 ± 7.1 | 22.9 ± 6.6‡ | 24.0 ± 6.2 | 25.5 ± 9.1 |
| Fat mass, kg | 19.6 ± 12.4 | 19.6 ± 11.8 | 18.6 ± 10.5 | 20.4 ± 10.3 |

BSA = body surface area
*$p$=0.0334.
†$p$=0.0028.
‡$p$=0.0036.

**Table 3.** Bioelectrical impedance parameters.

| | Hemodialysis | | Peritoneal dialysis | |
|---|---|---|---|---|
| | Initial | Final | Initial | Final |
| Weight, kg | 74.6 ± 18.8 | 73.7 ± 18.0 | 74.9 ± 15.6 | 78.0 ± 17.6 |
| Resistance, ohm | 532 ± 112 | 553 ± 116* | 508 ± 105 | 498 ± 105 |
| Reactance, ohm | 47 ± 16 | 46 ± 16 | 43 ± 14 | 46 ± 17 |
| Phase angle | 5.06 ± 1.67 | 4.83 ± 1.40† | 4.88 ± 1.21 | 5.41 ± 2.45 |

*$p$=0.0023.
†$p$=0.0481.

mass that may not be apparent by body weight monitoring. In hemodialysis patients body weight loss was identified as pertaining exclusively to the fat free and body cell mass compartments, while no changes were observed in fat mass (Table 3). In contrast, body weight gain in peritoneal dialysis patients was proportionally distributed among the three compartments studied (Table 3). The number of patients on peritoneal dialysis was smaller than those on hemodialysis. It is therefore possible that subtle differences in peritoneal dialysis during longitudinal follow up may have escaped statistical significance due to a type 2 error.

A few clinical studies have simultaneously evaluated body composition analysis by bioelectrical impedance and dual-energy x-ray absorptiometry (36-38). In general very good agreements were found by both methods in assessing fat mass and fat free mass. However, both methods are affected by the state of hydration (21,25, 30,32). It could be argued that the differences observed between hemodialysis and peritoneal dialysis patients in this study are related to a greater degree of overhydration in the latter when compared to the former. The relationship found between the bioimpedance parameters reactance and phase angle and serum albumin concentration reflects the combined effect of volume expansion and malnutrition. This potential confounding factor was evaluated by bioelectrical impedance vector analysis (30). This method allows definition of the state of hydration of a given individual or group in comparison to a reference group (31). The sex and race adjusted vector plots presented in Figure 1 indicate that both hemodialysis and peritoneal dialysis patients have a greater degree of overhydration (vector displaced to the right) when compared to the general population (NHANES III). However, no differences in vector parameters were noted between hemodialysis and peritoneal dialysis patients indicating a similar degree of overhydration.




**Figure 1.** Bioimpedance vector analysis after adjustment for race and sex in NHANES III subjects and in peritoneal dialysis (PD) and hemodialysis patients (HD).

Biochemical parameters related to dialytic clearance and divalent ion metabolism were similar in both groups (Table 1). As reported previously, peritoneal dialysis patients had lower serum albumin concentrations than their hemodialysis counterparts. This is of interest considering that fat free and body cell mass was better preserved in peritoneal dialysis patients, and is consistent with current views of factors including dialysis modality in addition to malnutrition impacting serum albumin concentrations (8-10,33-35).

In conclusion, bioelectrical impedance analysis is a practical clinical tool for evaluating body composition in dialysis patients.

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