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The Use of Bioelectrical Impedance Analysis for Monitoring Body Composition Changes During Nutritional Support

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Abstract: Body composition was measured with bioelectric impedance analysis (BIA) in 30 patients with protein malnutrition following biliopancreatic diversion. Determinations were carried out prior to, during, and at the completion of intravenous nutritional support when the nutritional parameters had completely reverted to normal. Before treatment, body weight (BW), lean body mass (LBM), and body fat (BF) values were similar to those of controls, whereas the total body sodium/total body potassium (TBNa/TBK) and extracellular mass/body cell mass (ECM/BCM) ratios were considerably higher. During the support, no changes in BW, LBM, and BF were demonstrated, although a sharp decrease of TBNa/TBK and ECM/BCM was observed, thus demostrating improved LBM composition. At the end of parenteral feeding, the BW, LBM, and BF values were similar to those observed before the support, while a further decrease in TBNa/TBK and ECM/BCM demonstrated a recovery towards normal of body composition. The full correspondence between clinical and BIA findings therefore suggests that this method may be valuable for monitoring body composition changes during nutritional support.

Key Words: bioelectric impedance analysis, nutritional assessment, body composition, parenteral feeding

Introduction

A method of routinely measuring body composition would be of great interest for assessing clinical nutrition. Being albumin and transferrin serum concentrations greatly influenced by the size of the extracellular space.

The recent availability of bioelectrical impedance measuring instruments has made the assessment of human body composition totally safe, easier, faster, and less expensive than such cumbersome methods as hydrostatic weighing, the potassium-40 count, or dilution of the isotopes, tritium and deuterium. Recent trials have shown that resistance (R) is a reliable parameter for total body water (TBW) determination in healthy subjects.[1–4] Furthermore, a close relationship between total body reactance (Xc) and the ratios of total body sodium to potassium (TBNa/TBK), and extracellular mass to body cell mass (ECM/BCM) has also been found.[5,6] Therefore, the values derived from body impedance analysis (BIA) instruments may be useful for the evaluation of body composition in clinical practice and survey research. However, in appraising the methods for qualitative and quantitative body composition assessment, the question arises over the reliability of BIA findings in subjects with gross nutritional alterations; that is, in populations vastly different from those in which the BIA equations were obtained. Notwithstanding, the characteristics of the BIA technique allow essentially universal application, thus greatly facilitating the comparisons between body composition data and clinical findings.

In this study, bioelectrical impedance was measured in a fairly homogeneous group of patients with protein malnutrition following biliopancreatic diversion (BPD), an effective surgical method to treat morbid obesity, consisting of an extended distal gastrectomy with a very long Roux-en-Y reconstruction 50 cm from the ileocecal valve.[7] The operation usually achieves a satisfactory weight loss, which is maintained long-term, without any severe metabolic disturbances. However, in about 10% of cases a protein malnutrition occurs within the second postoperative year, requiring a 20- to 30-day period of parenteral feeding.

This investigation was conducted to determine if BIA measurements are useful for detecting the changes in body composition of BPD patients with protein malnutrition during nutritional support.

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Materials and Methods

This study was carried out in 30 subjects, being 8 males and 22 females with a mean age of 30 years, ranging from 20 to 52 years, following BPD. The mean postoperative time was 10 months, with a range of 3–8 months. Evidence of protein malnutrition was seen clinically as asthenia, edema, anemia, and hair loss, and biochemically as a serum albumin of less than 3.2 g/dl and a serum transferrin of under 200 mg/dl. After evaluation of the nutritional status, intravenous support was commenced. Oral food intake was allowed ad libitum and assessed daily by an accurate alimentary interview, with 500–3,000 kcal and 10–,100 g of protein being assumed. In all cases, parenteral feeding mixtures were administered via a central line. The patients received 85 g of amino acids and 550–2,100 kcal daily, being 50%–100% fat, the amount of kilocalories depending on the individual food intake, whereas the oral plus parenteral intake was always greater than 2,500 kcal/day. Nutritional support was given for 18–32 days, with a mean of 22 days, and was discontinued when the nutritional parameters had reverted to normal (Table 1).

Bioelectrical total body impedance values were measured with a tetrapolar system (BIA 109, Akern-RJL), by injecting a 50 Khz, 800 mcA current from a pair of electrodes placed on the dorsum of the hand and foot, with a second set of proximal sensing electrodes.[3] Lean body mass (LBM) was calculated from the values of height (H), body weight (BW), and R, using the manufacturer's equations.[4] Body fat (BF) was calculated from the difference between BW and LBM, and the TBNa/TBK and ECM/BCM ratio values were calculated from BW, H, and Xc.[5]

Data were collected prior to, 9–10 days from the commencement of, and at the completion of parenteral feeding, when laboratory and clinical findings demonstrated a full recovery from protein malnutrition. A group of 30 subjects with normal protein nutrition matched with the BPD patients for age, sex, H, and BW served as controls.

Table 1. Serum albumin and transferrin concentrations in the biliopancreatic diversion patients with protein malnutrition prior to, during, and following nutritional support

		Prior to nutritional support	At 9–10 days	Following nutritional support
Albumin	mean	2.7	2.9	3.7
(g/dl)	range	2.1–3.2	2.3–3.2	3.1–4.2
Transferrin	mean	135	172	265
(mg/dl)	range	65–202	98–212	198–312

Statistical analyses were performed with the Wilcoxon test for paired, and the Mann-Whitney U-test for independent comparisons. Relationships between body composition parameters and biochemical findings were evaluated by the Pearson correlation test.

Results

Mean and range values of BW, LBM, BF, TBNa/TBK, and ECM/BCM of the BPD patients and controls are listed in Table 2. Before the nutritional support, the BPD patients showed similar LBM and BF values to the controls, whereas the TBNa/TBK and ECM/BCM ratio values were considerably higher at $P < 0.001$ and $P < 0.0003$, respectively. At 9–10 days, a small reduction in the BW and LBM values was observed, being significant only for LBM ($P < 0.04$), while BF sizes remained essentially unchanged. Moreover, a steep decrease in TBNa/TBK and ECM/BCM ratios was noticed ($P < 0.03$), the values still being significantly higher than those of the controls ($P < 0.009$).

Upon discontinuation of the parenteral feeding and as the conventional nutritional parameters were within the normal range, the BW, LBM, and BF values showed a slight but not significant increase. In comparison with the values observed before treatment, BW and BF were slightly higher and LBM was similar. Finally, a further significant fall in TBNa/TBK and ECM/BCM ratio values was found ($P < 0.0001$). When all the data collected at the end of the nutritional support were compared to the controls, BW, LBM, and BF sizes were similar, while the TBNa/TBK and ECM/BCM ratios were still significantly higher ($P < 0.006$) than controls.

Both prior to and following the nutritional support, biochemical findings were completely unrelated to the body composition parameters (Table 3). The relationship between serum albumin and the ECM/BCM ratio is shown in Fig. 1.

Discussion

It is known that following BPD, about 10% of patients develop a protein malnutrition caused by insufficient protein intake and/or absorbtion,[7] without any concurrent disease which may influence the data. This group of patients thus represents an excellent investigational model for nutritional status and body composition during nutritional support.

Before refeeding, impaired nutritional status was evidenced by clinical and laboratory findings. However, according only to the LBM and BF values derived from R, the body composition could have been considered

Table 2. Body composition in the control subjects and in the biliopancreatic diversion patients prior to, during, and at the end of parenteral nutritional support

		BW	LBM	BF	TBNa/TBK	ECM/BCM
Prior to nutritional support	mean	78	51.4	25.9	1.98	2.22
	range	154–50	70.3–36	95–4.1	5.81–0.77	6.19–0.96
	SD	22	15	13.5	1.06	1.49
At 9–10 days	mean	74	48	26.2	1.7	1.93
	range	152–50	68–37.1	94–7.3	4.2–0.87	4.49–1.1
	SD	21	11	13.04	0.97	1.68
Following nutritional support	mean	81	51.1	29.8	1.45	1.76
	range	155–51	67.4–37	95–3.7	2.2–0.77	2.69–0.97
	SD	18	9	11.43	0.6	1.12
Controls	mean	78	50.5	27.7	1.16	1.37
	range	159–50	77.9–37.2	·90–2.2	1.6–0.82	2.1–1.1
	SD	11.6	10.2	5.9	9.54	0.62

BW, Body weight (kg); *LBM*, lean body mass (kg); *BF*, total body fat (kg); *TBNa/TBK*, total body sodium to total body potassium ratio (mEq/mEq); *ECM/BCM*, extracellular mass to body cell mass ratio (kg/kg)

Table 3. Lack of a statistically significant correlation between the biochemical findings and the body composition parameters

	Serum albumin		Serum transferrin	
	r	*P*	*r*	*P*
LBM	0.18	ns	0.22	ns
ECM/BCM	−0.002	ns	−0.18	ns
TBNa/TBK	−0.20	ns	−0.29	ns

LBM, Lean body mass (kg); *TBNa/TBK*, total body sodium to total body potassium ratio (mEq/mEq); *ECM/BCM*, extracellular mass to body cell mass ratio (kg/kg); *ns*, not significant

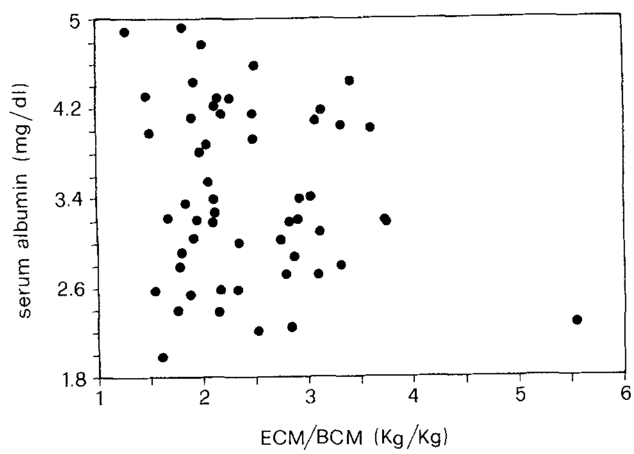

Fig. 1. Lack of correlation between the serum albumin concentration and the extracellular mass/body cell mass (*ECM/BCM*) ratio as assessed by bioelectric impedance analysis (*BIA*)

within the normal ranges. On the contrary, when the TBNa/TBK and ECM/BCM ratios were derived from Xc, the values were revealed to be substantially higher than those of controls, indicating a dilatation of extracellular spaces with a sharply contracted BCM size. Therefore, the body composition of these patients measured by both R and Xc is consistent with protein malnutrition.

During parenteral feeding, the reduction in LBM accounted totally for the decrease in BW with no changes in the fat content. The decrease of the TBNa/TBK and ECM/BCM ratios indicates a reduction in extracellular space and a relative increase in BCM. In fact, the concomitant reduction in the LBM value in comparison with the pretreatment findings suggests that the improvement in the qualitative composition of LBM during the first days of treatment was mainly due to the loss of extracellular fluid rather than the absolute increase in the BCM value. The reduction of extracellular space, and therefore the qualitative improvement of LBM, have then to be considered as the first step toward recovery from protein malnutrition.

The parenteral support was discontinued when the laboratory and clinical findings demonstrated a satisfactory nutritional status. By this time, body weight was slightly higher than either that before the support or that of the controls; the greater values being totally accounted for by BF, with similar LBM values. The marked decrease in TBNa/TBK and ECM/BCM ratios indicates further improvement in the LBM composition; the LBM having been restored to values close to those observed prior to treatment, thereby showing a true increase in the BCM value.

Bioelectrical body composition analysis during nutritional support demonstrated a short-term loss of extracellular fluid without sizeable changes in the body cell mass. Over a longer term, further improvement in

LBM composition occurred, with an absolute increase in the BCM value. However, when compared with the controls, body composition after the support still revealed abnormal results. Although the BW, LBM, and BF values were very similar, the TBNa/TBK and ECB/BCM values were substantially higher, demonstrating an extracellular space larger than normal or a smaller BCM. These results are in keeping with previous investigations using multiple dilutional techniques which revealed that BPD subjects with protein malnutrition achieved considerable improvement in body composition after nutritional support, but did not achieve complete normality, despite full restoration of serum albumin and transferrin concentrations.[8]

The lack of correlation between the biochemical findings and body composition parameters is not surprising. Serum albumin and transferrin concentrations reflect the body actual protein status, which is not strictly proportional to the body sectors size. However, the fact that the normalization of biochemical parameters corresponds to a return towards the normality of the body sectors suggests that nutritional support improves both protein status and body composition.

In conclusion, the results of BIA corresponded closely with both the clinical findings and the data from dilutional studies, thus appearing to be a reliable method for monitoring the changes in body composition during nutritional support.

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