Percentage Body Fat Determination in Hemodialysis and Peritoneal Dialysis Patients: A Comparison

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Objective: To evaluate percentage body fat in hemodialysis (HD) and peritoneal dialysis (PD) patients.

Design: A prospective study of 20 HD patients and 20 PD patients.

Setting: Sol Goldman Renal Therapy Center, Lenox Hill Hospital, New York, NY; Baumritter Kidney Center Albert Einstein College of Medicine, Bronx, NY; Body Composition Unit, St Luke's Roosevelt Hospital, Columbia University, New York, NY.

Patients: Twenty HD (10 men, 10 women) patients, mean age 41.8 ± 2.4 years and 20 PD (12 men, 8 women) patients, mean age 48.6 years ± 3.0 years.

Intervention: This is a noninterventional study. Patients signed consent to undergo dual-energy x-ray absorptiometry, total body potassium counting bioelectrical impedance analysis, total body water determination, and anthropmetric evaluation.

Main outcome measures: Present and compare percentage body fat between HD and PD patients as determined by the methods used.

Results: Percentage fat is not different between HD and PD patients. Differences in absolute values of percent fat between techniques exist.

Conclusion: HD patients and PD patients may be evaluated by the methods of body composition used. Percentage body fat will vary among techniques; therefore the same method should be used to follow a patient over time.

DIALYSIS PROFESSIONALS are struggling to identify the ideal means for assessing the nutritional integrity of their patients. Use of body composition assessment (BCA) to determine baseline data and serial information on dialysis patients who were studied hold clinical promise in revealing information about nutritional status. BCA has been widely used for the epidemiological studies of groups; however, its application for clinical practice is relatively new and less understood.[1,2]

Inherent in the use of the body composition models is the application of specific methodologies, assumptions, and constants. These factors will then influence the predicted body composition analysis. All methodologies divide the body into compartments. Several models exist for this.

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In the two compartment model, which is most commonly used, the body weight is comprised of the fat and fat-free mass. As described by Heymsfield and Matthews,[3] other more complicated models exist, which divide the body into more than two compartments.

The methods most commonly used for body composition analysis are anthropometrics, bioelectrical impedance analysis (BIA), and dual-energy x-ray absorptiometry (DXA). Other methods such as total body water (TBW) determination, total body potassium (TBK) counting, underwater weighing, total body conductivity, and neutron activation analysis are limited to the research laboratory and are often used for validation of the simpler body composition techniques.[4] Each method must be validated within the population being studied because assumptions used to derive each technique's predictive equation may not be correct if applied to patients whose physiologies differ from the reference.[4] For example, TBW measurements, the TBK counting method, and densitometry measurements all assume a particular constant for the fat-free mass (FFM).[4,5] For TBW, the assumption is of a constant state of hydration; for TBK a specific concentration of potassium per fat-free mass is a gender-specific assumption; and for DXA a particular density of fat-free mass is assumed.[5] The remainder of the modalities are also based on assumptions. Previous reports have proven these assumptions to be incorrect when applied to a population outside of these well-defined normals. Specific recent reports address the elderly[6] and malnourished acquired immune deficiency syndrome patients.[7]

In our previous work with peritoneal dialysis patients, our group has shown that the methods of DXA, TBK, BIA, and anthropometrics by Steinkamp (STK) et al,[8] and Durnin (DUR) and Wormersely[9] provide the same results as those of normals, and these methods can be applied to peritoneal dialysis (PD) patients.[10]

As a continuation of this work, we evaluated the use of body composition methods in hemodialysis (HD) patients. The purpose of this study is to compare percentage body fat in stable HD patients with PD patients as determined by the following modalities: DXA, TBK, BIA, TBW, and two anthropometric equations that are based on different measurements: Steinkamp et al,[8] and Durnin and Wormersely.[9]

Methods

HD and PD patients were recruited from the Sol Goldman Renal Therapy Center at Lenox Hill Hospital, New York, NY and the Baumritter Kidney Center at Albert Einstein College of Medicine, Bronx, NY. At the time of the study, Lenox Hill Hospital had 100 HD patients and 35 PD patients. The census at Baumritter Kidney Center was 125 HD patients and 30 PD patients. All patients were stable with no hospitalization within 1 month of the study. PD patients also had no episodes of peritonitis within 1 month of the study.

Twenty HD subjects (10 men and 10 women) and 20 PD subjects (12 men and 8 women) were studied. Mean time on dialysis was the same for both groups (for HD, 52 months, range, 2 to 231 months, for PD, 22.5 months range, 1 to 148 months). Body mass index (BMI; $\text{Weight}_{kg}/\text{Height}_{M}^{2}$) was calculated for the study patients and the nonstudy patients of Lenox Hill Hospital and Baumritter Kidney Center. This calculation was performed to determine if the study patients were representative of the nonstudy patients. All body composition studies for a given patient were performed at St Luke's-Roosevelt Hospital Body Composition Unit, New York, NY within the same day. The study was approved by the Institutional Review Boards of Lenox Hill Hospital and Montefiore Medical Center of Albert Einstein College of Medicine. Each subject gave informed consent.

HD patients arrived for the studies on an off-dialysis day, having been dialyzed the day before the study. PD patients had emptied their abdomen of peritoneal dialysate fluid at 0800 hours the morning of the studies. All subjects were fasting. Height and weight were obtained with a precision of ± 0.5 cm and ± 0.2 kg, respectively. Each patient underwent DXA, TBK, BIA, TBW, and anthropometric measurements by the following two techniques: STK and DUR. Blood chemistries (Chem 20, Ektachem, Johnson and Johnson Clinical Diagnostic Systems Inc, Rochester, NY) were obtained within 1 week of body composition analysis. The method of each modality have been reported previously by our group.[10] The following is a general description of each.

DXA

A Lunar model DPX (Lunar DPA software 3.6, Madison, WI) uses x-rays of two distinct energy levels that are attenuated by fat and FFM to different extents. The relative attenuations of the two x-rays energies by the intervening fat and FFM are recorded, and equations supplied by the manufacturer are used to estimate the relative proportions of fat and FFM. These measurements are highly quantitative with precision (coefficient of variation, CV) in the range of 3% to 4% for fat.[11]

TBK

TBK was determined by using a whole body 40K scintillation counter.[12] This measurement provides an estimate for the body cell mass by measuring radioactive isotope 40K that exists naturally in the body.[13] Once TBK is counted, FFM is estimated by using the Forbes constant, which estimates that men have 68.1 mEq K^+/kg FFM and that women have 64.2 mEq K^+/kg FFM.[14,15] Fat mass was estimated as the difference between body weight and FFM. Fat as percent of body weight was then calculated.[5] The precision of these measurements range from CV = 4.7%-5.4%.[12]

BIA

An RJL Model 101 instrument (RJL Systems, Mt Clemens, MI) was used for this measurement. BIA applies the concept that measured impedance to an electrical current can be correlated to body density, and subsequently body density can be correlated to fat mass. Electrical conduction is related to the water and electrolyte distribution in the body because current is not conducted through fat.[16] This device introduces an imperceptible alternating electrical current (800 μA at 50 kHz) via distal electrodes installed on the dorsal surface of the ipsilateral hand and foot; a voltage drop is detected by electrodes placed proximally on the same hand and foot. Impedance (resistance and reactance) were obtained.

Once resistance and reactance were determined, correlation equations were used to determine body density.[17] Percentage of fat was estimated from density by applying the Siri equation.[18] The precision of this technique is reproducible to ±0.5% for the measurement of resistance and ±1% for fat.[19]

TBW

TBW was determined by using the isotope dilution technique. TBW was measured as the 3-hour distribution of radioactive water 3 H_2O (200 μc). This is known as the radiosulfate washout technique. Details of this technique have been outlined previously.[20] The precision of this methods is 2.8%.[20]

Anthropometrics by Steinkamp (STK)

Height, weight, seven circumferences, two limb lengths, five diameters, and four skinfold thicknesses were used in this method that applies different equations according to age, gender, and race to estimate body fat. The standard error of the estimate of body fat was 2.0 to 3.8 kg. Measurements were obtained by two skilled examiners by using standard techniques as previously described.[8]

Anthropometrics by Durnin and Womersley (DUR)

This method was used to predict body density by using the logarithmic transformation of the sum of the following four skinfolds: triceps, biceps, subscapula, and iliac crest. Skinfold measures were obtained by two skilled examiners by using standard techniques with Lange skinfold calipers (Cambridge Scientific Instruments, Cambridge, MD). The precision of this method is reported to be approximately 3.5% for percent body fat.[9]

Statistics

Values are expressed as the mean ± standard error of the mean (SEM). To determine differences between groups and genders, a two-way analysis of variance (ANOVA) (gender and type of dialysis as factors) was performed after adjusting for age and time on dialysis as covariates. If an interaction term was noted in the ANOVA, independent sample t-tests were used to determine whether men or women differed within treatment groups. An alpha level of 0.05 was established for statistical significance.

Results

The clinical characteristics and baseline laboratory data of the PD patients and HD patients are listed in Table 1. As shown in Table 1, age, (41.8 ± 2.4 *v* 48.6 ± 3.0 years, $P = .89$), weight (72.9 ± 3.2 *v* 73.6 ± 3.3 kg, $P = .87$), height (1.69 ± 0.2 *v* 1.67 ± 0.03 m, $P = .62$), and BMI (25.5 ± 1.0 *v* 26.4 ± 1.2 kg/m^2, $P = .57$) were

Table 1. Clinical Characteristics and Baseline Data

	PD Total	PD Men	PD Women	HD Total	HD Men	HD Women
n	20	12	8	20	10	10
Diab	6	4	2	4	1	3
Age (yrs)	41.8 ± 2.4	41.5 ± 3.5	37.9 ± 5.0	48.6 ± 3.0	49.8 ± 4.9	47.4 ± 3.3
Weight (kg)	72.9 ± 3.2	79.7 ± 3.6	56.1 ± 7.2	73.6 ± 3.3	75.1 ± 3.8	72.2 ± 5.1
Height (m)	1.69 ± 0.02	1.74 ± 0.03	1.43 ± 0.17	1.67 ± 0.03	1.75 ± 0.02	1.6 ± 0.03
BMI (kg/m^2)	25.5 ± 1.0	26.2 ± 1.1	21.8 ± 3.0	26.4 ± 1.2	24.5 ± 1.2	28.3 ± 1.8

NOTE: mean ± standard error of the mean.
Abbreviations: PD, peritoneal dialysis; HD, hemodialysis; Diab, Diabetes Mellitus; BMI, body mass index.

not different between HD and PD patients. The HD and PD groups were characterized by gender. Data were analyzed by 2 way ANOVA. There was an effect of gender ($P < .5$) for weight and height but no effect of dialysis for age ($P < .097$), weight ($P < .86$), or BMI ($P < .56$). There was no significant interactive terms for age ($P < .79$), weight ($P < .86$), height ($P < .51$), and BMI ($P < .07$). In addition, the BMI for the combined populations of Lenox Hill Hospital and Baumritter Kidney Center were compared with the study population. There was no significant difference between the BMI of our sample population and nonstudy dialysis population, PD men ($P = .76$), PD women ($P = .31$), HD men ($P = .79$), HD women ($P = 0.10$). This suggests that the study population was representative of the nonstudy dialysis population.

The mean percentage fat by gender and condition is shown in Table 2. There was no difference in percentage fat between the PD and HD patients. In addition, there was no significant effect of condition (PD *v* HD) on body fat measurement, but there was a significant effect of gender, with women having higher percentage of fat ($P < .01$). There were no significant interaction terms.

Discussion

We have shown that percentage fat is not different between PD patients and HD patients. This result is striking. Our original work was driven by the research bias that PD patients became fat compared with HD patients. The apparent fatness of the peritoneal dialysis patient has been well described and is thought to be related to the glucose load from the peritoneal dialysate solution.[21,22] In contrast, HD patients are considered to be catabolic, which would result in weight loss and muscle wasting.[23] Guitterez et al[24] has shown that even sham HD can induce a catabolic state. Our results show that PD patients are not fatter than hemodialysis patients.

Although there was no difference in percentage fat between dialysis modalities, there was a difference by technique. TBW predicted the lowest percentage fat compared with TBK, which predicted the highest percentage of fat in men and women, in both PD and HD (see Table 2). This

Table 2. Percentage Fat by Five Different Techniques in Peritoneal Dialysis Patients and Hemodialysis Patients

	TBW	BIA	DXA	DUR	STK	TBK
Men						
PD (n = 12)	15.6 ± 2.6	17.1 ± 2.2	21.1 ± 2.3	22.3 ± 2.5	32.1 ± 1.8	38.6 ± 2.0
HD (n = 10)	22.1 ± 2.6	23.1 ± 1.4	24.3 ± 2.8	22.4 ± 2.0	27.3 ± 3.0	35.2 ± 2.8
Women						
PD (n = 8)	24.6 ± 4.7	28.6 ± 2.2	29.7 ± 4.8	32.1 ± 3.4	34.8 ± 3.2	46.6 ± 10.5
HD (n = 10)	28.8 ± 3.6	30.1 ± 2.1	35.5 ± 3.5	35.2 ± 3.1	40.1 ± 3.5	47.9 ± 2.7

NOTE: mean ± standard error of the mean.
Abbreviations: PD, peritoneal dialysis; HD, hemodialysis; TBW, total body water; BIA, bioelectrical impedance analysis; DXA, dual-energy x-ray absorptiometry; DUR, Durnin and Womersely; STK, Steinkamp; TBK, total-body potassium counting.

difference in percentage fat by each technique is not a new finding for our group or for other workers.[5,10,25] It is well known that variations in measurements occur. Lukaski[5] has suggested that systematic errors caused by the assumptions intrinsic to each technique produce the variations. Jensen et al[25] reinforces this concept, explaining their findings of difference in absolute values of FFM as being caused by the different body compartments measured and variations in assumptions, not problems with the techniques themselves.

Finally, TBW was not measured in our initial work, therefore we have not validated this technique in PD patients, as we did with the other body composition techniques. We can limit our observation to stating that there is no difference in percentage body fat predicted by TBW between HD and PD patients.

Our previous experience indicates that the standard body composition measurement techniques we applied can be used in stable PD patients. And now, we have shown that HD patient did not differ from PD patients. However, significant variation in percentage fat values result when different measurement techniques are used. This study was funded by the National Kidney Foundation Council of Renal Nutrition Research Grant and the National Kidney Foundation of New York/New Jersey Council of Renal Nutrition Research Grant.

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