Evaluation of Fat Tissue Measurement Methods for Nutritional Assessment in Chronic Hemodialysis Patients

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Abstract

Background. Estimation of body fat stores is an important part of nutritional assessment in hemodialysis patients. We studied the correlation of nutritional assessment methods, including biochemistry, anthropometry, bioelectrical impedance analysis (BIA) and ultrasonographic abdominal fat thickness measurements in hemodialysis patients.
Methods. We studied 20 (14 men / 6 women; mean age 47.1±14.9 years) clinically stable chronic hemodialysis patients. Predialysis serum albumin, creatinine, urea, total cholesterol, triglyceride and transferrin levels were determined. Body mass index (BMI), waist, hip and arm circumference, skin fold thicknesses (SKF) were measured. After hemodialysis session, BIA was performed using a single frequency (50 kHz) device. Fat mass was calculated with SKF and BIA. BIA was also used to calculate the fat mass of 35 healthy controls. Abdominal subcutaneous, preperitoneal and intraabdominal visceral fat tissue thicknesses were measured with ultrasound. The associations between anthropometry, biochemistry, BIA and ultrasonographic measurements variables were evaluated.
Results. Fat mass of the patients was lower than that of the controls. Fat mass calculated from SKF and BIA was 14.0±5.2 kg and 12.5±5.4 kg respectively and these values were not statistically different (P=0.07). There was a good correlation between the fat mass estimates made by SKF and BIA (r: 0.81, P <0.001). Fat mass estimates showed a good and significant correlation with basic anthropometric measurements such as hip and arm circumference and BMI. Among the biochemical parameters only triglyceride levels correlated with the fat mass estimated by BIA (r: 0.50, P<0.05). Ultrasonographic measurements generally showed a fair correlation with fat mass that was estimated with BIA.
Conclusions. Both BIA and SKF are simple and practical methods that can be applied for the assessment of nutrition in hemodialysis patients. BMI, hip and arm circumference seem to be useful markers of the nutritional status.

Key words: bioimpedance analysis, fat mass, hemodialysis, nutrition, skinfold thickness, ultrasound
Running title: Fat mass in hemodialysis patients

Introduction

Malnutrition is highly prevalent in hemodialysis patients and it is associated with an increased risk of morbidity and mortality (1, 2). Practical and sensible indicators of body composition are needed for the assessment of malnutrition. Traditionally, biochemical and anthropometric measurements are used for the assessment of nutritional status. Moreover, in recent years bioimpedance analysis (BIA) has gained an increased popularity for the assessment of nutritional status (3-5). Additionally, dual-Energy X-ray absorbtiometry (DEXA), neutron activation analysis and nuclear magnetic resonance spectroscopy have also been used for nutritional assessment in hemodialysis patients (1, 2). However cost and availability concerns limit the widespread use of these advanced techniques.
Estimation of body fat stores is an important part of nutritional assessment. Beside above-mentioned techniques imaging modalities such as computed tomography (CT) and ultrasonography, were successfully used for the estimation of body fat stores (6, 7). Upper arm fat tissue thickness as measured by ultrasonography has been used for the assessment of malnutrition previously (8). In obese patients, ultrasonographic abdominal fat tissue thickness measurement was found to be a useful tool for monitoring the changes in body fat mass (9). However, to the best of our knowledge, no previous study had examined the validity of ultrasonographic method for nutritional assessment, in hemodialysis patients.
In this study, we evaluated the correlation between the classical nutritional assessment methods, including biochemistry, anthropometry, bioelectrical impedance analysis (BIA) and ultrasonographic abdominal fat thickness measurements in chronic hemodialysis patients.

Patients and Methods

We studied 20 clinically stable, chronic hemodialysis patients who were followed up at our hemodialysis unit. Exclusion criteria were as follows; duration of hemodialysis less than 3 months, hospitalization in the month prior to the beginning of the study, history of a cerebrovascular accident, malignancy and limb amputation.
Serum albumin, creatinine, urea, total cholesterol, triglyceride and transferrin were measured using an autoanalyzer (Olympus AU 800; Olympus Diagnostica GmhH, Hamburg, Germany) by the blood drawn for routine analysis before the hemodialysis session.
All anthropometric measurements were performed after a routine hemodialysis session. Weight, height, waist, hip and arm circumference were performed. Body mass index (BMI) was calculated as weight (kilograms)/ height^2 (meters). Skinfold thicknesses (SKF) were measured at four standard sites (biceps, triceps, subscapular and suprailiac) on the opposite side of the vascular access using a Saehan skinfold

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caliper (Saehan Company, Korea). Averages of the three measurements for each site were used to calculate percentage of body fat mass according to Durnin and Womersley formula and Siri's equation (10, 11).

BIA was performed approximately 30 minutes after hemodialysis session by using a single frequency (50 kHz) bioimpedance analyser (BIA-450, Biodynamics corp, CA, USA). The electrodes were placed in the standard tetrapolar positions to the non access side of the patient. Resistance and reactance were directly measured and the body fat mass values were calculated by the integrated software of the equipment. BIA was also used to calculate the fat mass of 35 healthy controls.

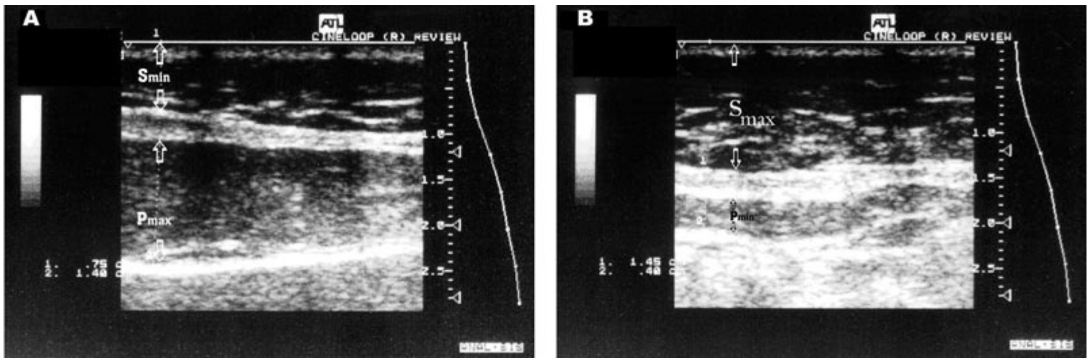

Figure 1. (A) Ultrasound image obtained below the xiphoid process to measure the minimum subcutaneous fat thickness (Smin) and the maximum preperitoneal fat thickness (Pmax). (B) Ultrasound image obtained just above the umbilicus to measure the maximum subcutaneous fat thickness (Smax) and the minimum preperitoneal fat thickness (Pmin).

Abdominal subcutaneous and preperitoneal fat tissues were measured using a 5-10 mHz linear array transducer (ATL, Ultramark HDI 9, USA). Longitudinal scans were obtained from upper median abdomen. The maximum subcutaneous and minimum preperitoneal fat thicknesses were measured at 5 cm above the umbilicus (Figure 1A). The minimum subcutaneous and maximum preperitoneal fat thicknesses were measured just below the xiphoid process (Figure 1B). Intraabdominal visceral fat tissue thickness was measured just above the umbilicus between the posterior aspect of the abdominal wall and the anterior wall of the abdominal aorta using 3.5 mHz convex array transducer (Figure 2).

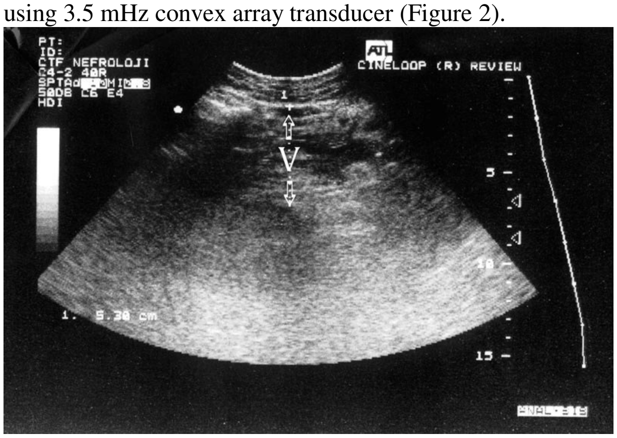

Figure 2. Transverse ultrasound image, obtained just above the umbilicus, to measure the visceral fat tissue thickness (V) between the posterior aspect of the abdominal wall and anterior wall of the aorta

All anthropometric measurements and BIA were performed by one of the investigators (KA) and all ultrasound examinations were carried out by another investigator (SN). Each observer was blind to the results of the other observer.

The data are expressed as mean ± SD. Continuous variables were compared using Student's t test or Mann-Whitney U test, when appropriate. The associations between ultrasonographic measurements and anthropometry, biochemistry, BIA variables were evaluated by means of Spearman's rank correlation (r). In addition, Bland-Altman plot analysis was performed for the assessment of agreement between the BIA and SKF. All tests were performed using SPSS for Windows, version 10.0, software (SPSS Inc, Chicago, IL). P less than 0.05 was considered statistically significant.

Results

Clinical data and biochemical parameters of the 20 study participants are shown in Table 1. These study parameters were not statistically different between male and female patients. Causes of end-stage renal disease were chronic glomerulonephritis in six (30%), chronic pyelonephritis in three (15%), hypertensive nephrosclerosis in two (10%), polycystic kidney disease in two (10%), miscellaneous in two (10%) and unknown in five patients (25%).

Table 1. Clinical data and biochemical parameters of the patients*.

	Total (n=20)	Male (n=14)	Female (n=6)	P
Age (years)	47.1±14.9	49,8±13,8	40,8±16,8	0.22
Duration of hemodialysis (months)	40.6±48.2	45,1±53,6	30,2±34,4	0.54
Urea (mg/dl)	154±40.2	158.7±36.5	143.2±49.8	0.44
Creatinine (mg/dl)	10.1±2.7	10.3±2.9	9.7±2.6	0.66
Albumin (g/dl)	3.7±0.3	3.7±0.3	3.8±0.2	0.88
Total cholesterol (mg/dl)	186.7±44.3	187.9±45.9	184±44.5	0.86
Triglyceride (mg/dl)	192.8±90	186.6±59.6	207±145.7	0.65
Transferrin (mg/dl)	161.7±20.1	166±18.3	151.8±22.5	0.15

*Data are expressed as mean ± SD

Table 2. Anthropometric, BIA and ultrasonographic measurements of the patients*.

	Total (n=20)	Male (n=14)	Female (n=6)	P
Weight (kg)	66±8	66.9±5.8	63.8±1.2	0.45
Height (cm)	165.7±7.4	169.6±4.6	156.3±2.2	<0.001
BMI (kg/m^2)	24.2±3.7	23.3±2.4	26.2±5.5	0.26
SKF-triceps (mm)	10±5.5	9.1±5.3	11.9±5.8	0.21
SKF-biceps (mm)	6±2.8	5.5±1.8	7.1±4.4	0.90
SKF-subscapular (mm)	10.2±5.1	10.5±4.6	9.6±6.6	0.78
SKF-suprailiac (mm)	9.5±5.3	8.2±2.8	12.5±8.4	0.44
SKF-Fat mass (kg)	14.0±5.2	12.8±3.9	16.9±7.1	0.21
Arm circumference (cm)	27±3.1	26.9±2.2	27.4±4.8	0.97
Waist circumference (cm)	86.3±9.8	88.3±8.0	81.7±12.7	0.21
Hip circumference (cm)	96.6±5.5	95.3±4.7	99.7±6.5	0.35
Resistance (ohms)	568.9±86.7	570.9±87.2	564.3±93.6	0.84
Reactance (ohms)	70.2±17.3	75.1±15	58.8±18.1	0.03
Phase angle (degree)	7.0±1.2	7.5±0.8	5.9±1.3	<0.01
BIA-Fat mass (kg)	12.3±5.4	12.2±5	13.5±6.9	0.84
S-min (cm)	1±0.6	1.1±0.4	0.9±0.9	0.08
S-max (cm)	1.8±1	1.8±0.7	1.8±1.5	0.24
P-min (cm)	0.5±0.4	0.4±0.1	0.9±0.6	0.07
P-max (cm)	1.2±0.5	1.1±0.5	1.4±0.6	0.44
Visceral (cm)	4.4±1.6	4.6±1.4	4.1±2.2	0.60

*Data are expressed as mean±SD. BMI, Body mass index; SKF, Skinfold thickness; BIA, Bioimpedance analysis; S-min, minimum thickness of subcutaneous fat; S-max, maximum thickness of subcutaneous fat; P-min, minimum thickness of preperitoneal fat, P-max, maximum thickness of preperitoneal fat.

Results of BIA, anthropometric and ultrasonographic measurements are shown in Table 2. In twelve patients (60%) BMI was between 18.5 and 25 kg/m^2, in seven patients BMI was ≥25 kg/m^2 and in the remaining one patient the BMI was calculated as 18.2 kg/m^2. Males were taller then females, had higher phase angle and reactance values (Table 2). The remaining study parameters were similar between the two sexes. Fat mass of the patients was lower than that of the controls (12.6±5.5 kg vs 18.8±7.0 kg; P<0.01). Demographic data, BIA measurements and fat mass calculated by BIA for the patient and control groups stratified by gender are shown in Table 3. Control and patient groups were similar regarding the age, height, weight and BMI, however fat mass of the patient group was lower than that of the control group. This difference was statistically significant in female subjects.

Table 3. Comparison of patient and control groups, stratified by gender*.

	Male			Female		
	Patients (n=14)	Controls (n=20)	P	Patients (n=6)	Controls (n=15)	P
Age (years)	49.8±13.8	47.4±3.2	0.54	40.8±16.8	38.9±6.0	0.79
Weight (kg)	66.9±5.8	72.5±12.7	0.13	63.8±12.1	71.3±12.5	0.22
Height (cm)	169.6±4.6	169.0±6.9	0.76	156.3±2.2	159.7±5.9	0.18
BMI (kg/m^2)	23.3±2.4	25.4±4.1	0.09	26.2±5.5	28.0±5.1	0.49
Resistance (ohms)	570.9±87.2	478.2±75.4	<0.01	564.2±93.6	533.5±82.4	0.46
Reactance (ohms)	75.1±15.0	61.1±11.9	<0.01	58.8±18.1	66.5±13.9	0.30
Phase angle (degree)	7.5±0.83	7.3±0.97	0.55	5.9±1.3	7.1±1.1	0.04
Fat mass (kg)	12.2±5.0	15.6±5.4	0.07	13.5±6.9	23±6.9	0.01

*Data are expressed as mean±SD. BMI, Body mass index

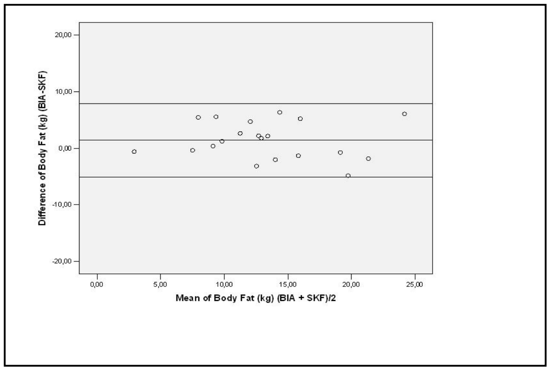

Figure 3. Bland-Altman plot analysis to evaluate the agreement between the methods of Skinfold thickness (SKF) and BIA for the assessment of body fat in hemodialysis patients. The differences of body fat in kilograms are plotted against the mean of body fat obtained the two methods.

In hemodialysis patients fat mass calculated from the anthropometric measurements and BIA was 14.0±5.2 kg and 12.5±5.4 kg, respectively and these values were not statistically different (P=0.07). We found a good correlation between the fat mass estimates made by SKF and BIA (r: 0.81, P <0.001). Bland-Altman plot showing the agreement between fat mass estimations made by BIA and SKF measurements is shown in the Figure 3. The mean differences and limits of agreement were the following: 2.3±5.1 (-7.9 to 12.5) kg for the whole group. The mean differences for men and women were 0.56±2.9 and 3.5±3.6 kg, respectively.

The correlations of biochemical data, basic anthropometric and ultrasound measurements with fat mass estimates are shown in Table 4. Fat mass estimates showed a good and significant correlation with basic anthropometric measurements. On the other hand, among the biochemical parameters only triglyceride levels correlated with the fat mass estimated by BIA, however, there were no statistically significant correlation between the remaining biochemical parameters and fat mass (Table 4). Ultrasonographic measurements generally showed a good correlation with fat mass that was estimated with BIA.

Table 4. Association between the fat mass and anthropometric, biochemical, ultrasonographic measurements*.

	Fat Mass			
	SKF		**BIA**	
	r	**P**	**R**	**P**
BMI	0.88	<0.001	0.72	<0.001
Arm circumference	0.78	<0.001	0.70	<0.01
Waist circumference	0.48	0.032	0.60	<0.01
Hip circumference	0.76	<0.001	0.69	<0.01
Albumin	0.06	0.81	0.11	0.66
Total cholesterol	0.09	0.71	0.33	0.15
Triglyceride	0.30	0.21	0.50	0.047
Transferrine	0.16	0.52	0.22	0.35
S-min.	0.20	0.41	0.46	0.04
S-max.	0.35	0.15	0.53	0.02
P-min.	0.72	<0.01	0.50	0.03
P-max.	0.43	0.06	0.32	0.17
Visceral	0.32	0.18	0.48	0.034

*Statistically significant associations are written in bold letters. SKF, Skinfold thickness; BIA, Bioimpedance analysis; BMI, Body mass index; S-min, minimum thickness of subcutaneous fat; S-max, maximum thickness of subcutaneous fat; P-min, minimum thickness of preperitoneal fat, P-max, maximum thickness of preperitoneal fat.

Discussion

Fat mass reflects the energy stores of an individual therefore; assessment of body fat mass is an important part of nutritional evaluation. Body fat mass is estimated by several methods. SKF measurement is a long established and inexpensive method and it is very useful in the clinical practice for the assessment of body fat in chronic hemodialysis patients (4). The main limitation of this method is its operator dependency (12). However, according to a recent study, SKF measurements showed a good agreement with DEXA (4). BIA is another practical method of body composition analysis. BIA shows a good correlation with anthropometric measurement especially in men (4, 5). We found lower fat mass values, especially in female hemodialysis patients compared to healthy controls. This finding reflects reduced energy stores of these patients.

In this study we used the routine accessible methods of predicting fat mass, SKF and BIA for detecting the similarity among the techniques for the assessment of body fat in hemodialysis patients. The agreement between the two methods as evaluated by Bland-Altman plot analysis was not as good as previously reported when the whole population was analyzed (4). In line with previous data this relatively poor disagreement can be explained by the differences observed mainly in women (4, 5). On the other hand, there was a good and statistically significant correlation between the two methods; moreover the mean fat mass estimates by these two methods were not statistically different. We did not use a reference method such as DEXA therefore we could not speculate about the accuracy of BIA or SKF.

CT has been also considered an accurate and reproducible method of body fat measurement (13). However this method is costly and involves exposure to ionizing radiation. Because of these limitations a variety of alternative imaging methods were used for the assessment of body fat. Previous works indicate that ultrasonography can be used reliably to measure abdominal fat tissue (6, 7). In a follow up study, all the abdominal subcutaneous, preperitoneal and visceral fat layers decreased during weight loss in obese patients (9).

To the best of knowledge no previous study had examined the value of ultrasonographic measurement of fat tissue for nutritional evaluation in hemodialysis patients. We evaluated the correlation between fat mass and ultrasonographic measurements. We found that the ultrasonographic abdominal fat tissue thicknesses showed fair correlation with fat mass. Interestingly, some very simple anthropometric measurements such as hip and arm circumference and BMI showed very good correlation with fat mass. Therefore we want to point out the importance of these simple parameters for daily clinical practice.

Predialysis urea, creatinine, albumin, prealbumin, transferrin, triglyceride and total cholesterol levels were also used for the evaluation of nutritional status in hemodialysis patients (14). In our study among biochemical parameters only triglyceride level showed a statistically significant correlation with the fat mass estimated by BIA. In line with some previous work we did not found a correlation between albumin levels and the nutritional status (15, 16).

We evaluated some accessible methods that were commonly used for the evaluation of nutritional status in hemodialysis patients. Moreover, for the first time we evaluated the value of ultrasonography for fat mass estimation in hemodialysis patients. The cross-sectional nature and relatively small sample size were the main limitations of our study.

Conclusion

In conclusion, both BIA and SKF are simple and practical methods that can be applied for the assessment of nutritional status in hemodialysis patients. Especially in male patients they show a good agreement for the estimation of fat mass. Some very simple anthropometric measurements especially hip circumference and BMI can be used in the daily clinical practice for the estimation of fat mass. Ultrasonographic abdominal fat thickness measurement is more costly and requires an operator with sufficient technical proficiency therefore more study is needed before recommending its use for nutritional assessment in hemodialysis patients.

References

1. Pupim L, Martin CJ, Ikizler TA. Assessment of Protein-Energy Nutritional Status.In: Kopple JD, Massry SG eds: Nutritional Management of Renal Disease, *Lippincott Williams & Wilkins, Philadelphia, PA*; 2003; 223-40
2. Locatelli F, Fouque D, Heimburger O, et al. Nutritional status in dialysis patients: a European consensus. *Nephrol Dial Transplant* 2002; 17: 563-72
3. Maggiore Q, Nigrelli S, Ciccarelli C, et al. Nutritional and prognostic correlates of bioimpedance indexes in hemodialysis patients. *Kidney Int* 1996; 50: 2103-8
4. Kamimura MA, Avesani CM, Cendoroglo M, et al. Comparison of skinfold thickness and bioelectrical impedance analysis with dual-enerjy X-ray absorptiometry for the assessment of body fat in patients on long-term haemodialysis therapy. *Nephrol Dial Transplant* 2003; 18:101-5
5. Kamimura MA, Jose Dos Santos NS, Avesani CM, et al. Comparison of three methods for the determination of body fat in patients on long-term hemodialysis therapy. *J Am Diet Assoc*. 2003; 103: 195-199
6. Armellini F, Zamboni M, Rigo L, et al. The contribution of sonography to the measurement of intra-abdominal fat. *J Clin Ultrasound*. 1990; 18 (7): 563-7
7. Armellini F, Zamboni M, Robbi R, et al. Total and intra-abdominal fat measurement b ultrasound and computerized tomography. *Int J Obes Relat Metab Disord* 1993; 17: 209
8. Koskelo EK, Kivisaari LM, Saarinen UM, Siimes MA. Quantitation of muscles and fat by ultrasonography: a useful method in the assessment of malnutrition in children. *Acta Paediatr Scand*. 1991; 80 (6-7): 682-7
9. Sabir N, Pakdemirli E, Sermez Y, et al. Sonographic assessment of changes in thickness of different abdominal fat layers in response to diet in obese women. *J Clin Ultrasound*. 2003; 31 (1): 26-30
10. Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *Br J Nutr* 1974; 32: 77-97
11. Siri WE. Body composition from fluid space and density analysis of methods. In: Brozek J, Henschel A, eds. Techniques for Measuring Body Composition. Washington, DC: *National Research Council*, 1961: 223-244
12. Heymsfield SB, Baumgartner RN, Pan SF. Nutritional assessment of malnutrition by anthropometric methods. In: Shils ME, Olson JA, Shike M, Ross AC, eds. Modern Nutrition in Health and Disease. *Lippincott Williams & Wilkins, Baltimore, MD*, 1999; 895-902
13. Busetto L, Baggio MB, Zurlo F, et al. Assessment of abdominal fat distribution in obese patients: anthropometry versus computerized tomography. *Int J Obes Relat Metab Disord*. 1992; 16 (10): 731-6
14. Clinical practice guidelines for nutrition in chronic renal failure. K/DOQI, National Kidney Foundation. *Am J Kidney Dis* 2000; 35 (6 suppl 2): S1-S140
15. Heimburger O, Qureshi AR, Blaner WS, et al. Hand-grip muscle strength, lean body mass, and plasma proteins as markers of nutritional status in patients with chronic renal failure close to start of dialysis therapy. *Am J Kidney Dis*. 2000; 36 (6): 1213-25
16. Cano N, Fernandez JP, Lacombe P, et al. Statistical selection of nutritional parameters in hemodialyzed patients. *Kidney Int Suppl*. 1987; 22: S178-80