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Body composition and cardiovascular risk factors in pretransplant hemodialysis patients

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Summary *Background*: Obesity, hyperlipemia and cardiovascular complications contribute to a significant proportion of morbidity and mortality of renal transplant patients and have negative effects on renal survival. Aim of the present study was to evaluate the main abnormalities in body composition and the prevalence of some cardiovascular risk factors in a population of hemodialyzed (HD) patients awaiting renal transplantation.

Methods: We studied 151 HD patients, all included in a waiting list for renal transplantation, 97 males and 54 females, with mean age 47.4±12 years. Patients were divided into three groups according to their body mass index (BMI) (kg/m^2): 18.5 to 24.9 (normoweight, NW); 25.0 to 29.9 (overweight, OW); ⩾30 (obese, OB). The body composition measurements were obtained the day after the mid-week HD session using bioelectrical impedance analysis (BIA).

Results: We found that 47 patients were NW (31%), while 56 were OW (37%), and 48 were OB (32%). BIA-measured body cell mass was (BCM) significantly increased in the OW as compared with the NW group ($P<0.001$), but, of note, no significant difference was found in OB group in comparison with the OW. Total cholesterol and triglycerides plasma levels were significantly elevated in OW and OB patients with respect to NW ($P<0.05$) and an increased prevalence of diabetes was seen in OB patients (NW: 6%, OW: 5%, OB: 12%).

Conclusions: These data show that a large proportion of patients awaiting renal transplant are overweight or obese and a consistent part of them have other cardiovascular risk factors associated. Furthermore, obese HD patients have a BCM lower than predicted on the basis of BMI and show an altered metabolic profile. A better understanding of the characteristics of patients included in the renal

Abbreviations: BCM, body cell mass; BCM%, body cell mass as a percentage of body weight; BMI, body mass index; BIA, bioelectrical impedance analysis; BW, body weight; ECW%, extracellular water as a percentage of total body water; FFM, fat free mass; FFM%, fat free mass as a percentage of body weight; FM, fat mass; FM%, fat mass as a percentage of body weight; HD, hemodialysis; IBW, ideal body weight; PA, phase angle; TBW, total body water; PEM, protein energy malnutrition; ESRD, end stage renal disease

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transplant waiting list is crucial in order to design prospective studies that aim to define the proper risk profile for the selection of patients.

Introduction

Recent data show better survival in overweight and obese patients undergoing maintenance hemodialyisis therapy, as compared to normal and underweight patients. The survival advantage of being overweight, in hemodialysis patients is in contrast with the general population where overweight is accompanied with higher mortality rate. Also other traditional mortality risk factors, such as total cholesterol and hypertension, have shown a paradoxical behavior in hemodialysis patients. Recently, Cheung et al.[1] suggested that hypercholesterolemia and hypertension do not bear the cardiovascular disease in chronic hemodialysis patients as they do in the general population.

In contrast, in transplanted patients obesity, hyperlipemia and cardiovascular complications contribute to a significant proportion of morbidity and mortality and have negative impact on renal survival.[2] Pre-operative obesity has been reported to worsen the outcome of organ transplantation. Impairment of graft function as well as decreased patient and graft survival are associated with high BMI.[3] Metabolic factors also play an important role in the early or late graft loss after kidney transplantation. Low levels of serum cholesterol, triglycerides, and glucose, before and after transplantation, are accompanied by a prolonged graft survival; prognostic factors for early graft failure included serum triglycerides >300 mg/dl, cholesterol >250 mg/dl before transplantation.[4] Lower systolic and, particularly, lower diastolic blood pressure values are accompanied by prolonged graft function.[4] Additionally, a history of cigarette smoking has detrimental effects on graft survival and correlates with decreased patient survival after transplantation.[5] These aspects should be emphasized in patients with end-stage renal disease who are considered for renal transplantation.

Outcome differences in obese and non-obese renal transplant patients are primarily due to a higher mortality from cardiac events,[6] therefore appropriate patient selection is crucial to the success of kidney transplantation.

No studies are available about the prevalence of Framingham mortality risk factors, such as hypertension, smoke habit, lipids, body weight and body mass index in a population of hemodialyisis patients included in a waiting list for renal transplantation. Furthermore, there are no data concerning the body composition and the nutritional status of patients candidates to renal transplant. Aim of the present study was to evaluate the main abnormalities in body composition and the prevalence of some traditional risk factors for cardiovascular disease and their relationships to body mass index and food intake in a representative population of hemodialyzed pretransplant patients.

Methods

Subjects

This investigation was carried out in 151 patients included in the waiting list for renal transplant at the Transplantation Center of the University of Naples "Federico II", Italy, during the year 2001. Patients were first screened by the nephrologists of their dialysis unit and then evaluated by the transplantation team that followed the general clinical practice guidelines for the evaluation of renal transplant candidates.[7] The present study was then performed in all the hemodialysis patients included in the renal transplant active waiting list. Patients had the following characteristics: stable clinical conditions; absence of infections or of any acute illness in the last 3 months; constancy, for the last 3 months, of dialysis dose with the same treatment modality, of dietary intakes, body weight and routine laboratory measurements. Adult hemodialysis patients, 96 males and 54 females, with a mean age 47 ± 12 years and a BMI (kg/m^2) within the 19–56 range were studied. All the subjects gave their informed consent to the study that was approved by the Ethical Committee of the Medical School of the University Federico II of Naples. Anthropometric measurements included body weight (BW) and height (H). Body mass index, that is considered a reliable parameter to estimate obesity as risk factor,[8] was calculated as the ratio body weight/height^2 (in kg/m^2);[9] ideal body weight (IBW) was calculated from the Metropolitan Life Insurance Tables (Metropolitan Life Insurance CO., 1983). Patients were divided into three groups according to the value of BMI: 18.5 to 24.9 (normoweight, NW); 25.0 to 29.9 (overweight, OW); ⩾30 (obese, OB).[10] All patients were following a free intake of calories and proteins.

WHO criteria for the diagnosis of diabetes mellitus were used[11] (fasting plasma glucose ⩾140 mg/dl). Only five patients had border-line plasma glucose levels and did not receive any treatment, all other patients that met the diagnostic criteria were treated with insulin.

To exclude major alterations of hydration status, the optimal dry weight was accurately achieved in each patient according to bioelectrical impedance analysis (BIA) measurements and clinical criteria: lowest weight at the end of HD session that the patient can tolerate without intradialytic symptoms (dizziness, cramps) and hypotension; absence of peripheral or pulmonary edema.[12] In order to minimize any distortion in BIA measures caused by fluid excess, patients were studied in the mid-week interval, the morning after the second hemodialysis session of the week (Wednesday or Thursday).

Patients were dialyzed for a mean of 240 min thrice weekly using cellulose modified membranes with surface area of 1.3–1.6 m^2, the vascular access was a native arterio-venous fistula in all of them. Blood and dialysate flow rates were 250–300 and 500 ml/min, respectively. The dialysis solution was bicarbonate-buffered, isotonic, with the temperature constantly kept around 37°C.

Usual intake was collected during a personal interview with an expert renal dietitian using a detailed food-frequency questionnaire of 130 foods and beverages.[13] Dietary protein intake obtained with this procedure was expressed in g/kg of ideal body weight.

Bioelectrical impedance analysis measures

In recent years bioimpedance has been shown as a valid method to study body composition and nutritional status in hemodialysis patients.[14–17] In this population, the role of BIA has been validated in nutritional assessment for the estimation of BCM.[14] In HD patients BIA-derived BCM and TBW strictly correlate with DEXA-derived BCM and D_2O dilution-measured TBW.[14] Furthermore, in these patients, the extent of FFM and FM assessed by BIA is comparable with the data obtained by measuring skinfolds thickness.[18,19]

BIA measurement was performed by the same investigators in all subjects. Single-frequency BIA was determined at 50 kHz and 800 μA (model BIA 101 RJL, Akern, Firenze, Italy) according to the standard tetrapolar technique; to avoid artefacts, the electrodes were placed on feet, ankles, hands and wrists on the side of the body free from the vascular access.[20]

The body composition measures were calculated from BIA measurements (resistance and reactance) and anthropometric variables (BW and H), using the software provided by the Akern/RJL Systems, as previously described.[21] This predictive model allows to calculate total body water (TBW), body fat-mass (BIA-FM) and fat-free mass (BIA-FFM), body cell mass (BCM) and extra-cellular water (ECW).

Biochemical and dialysis data

In all patients, fasting (at least 12 h) blood samples were drawn before the mid-week dialysis session to measure hemoglobin, hematocrit (Ht), and plasma levels of urea (reported as blood urea nitrogen, BUN), albumin, creatinine, cholesterol, high-density lipoprotein cholesterol (HDL-Col) and triglycerides, serum calcium, serum phosphorus. A sample was also obtained 2 min after the end of the same mid-week dialysis session to measure the BUN value. K_t/V, as measure of dialysis dose, was calculated by the following equation: [22] $-\ln(R - 0.008 \times T_{\mathrm{d}}) + (4 - 3.5R)$ UF/W, where: $R =$ BUN post-HD/BUN pre-HD, $T_{\mathrm{d}} =$ HD time (hours), UF = ultrafiltration volume, $W =$ body weight at end of dialysis session (kg). K_t/V is a dimensionless measure of dialytic dose, where K is the urea dialytic clearance (expressed in ml/ml), t is treatment time (in minutes) and V is the body volume cleared by urea at a rate K (V approximately equals total body water, that is, 58% of dry weight). The protein intake was calculated as normalized protein catabolic rate referred to the actual body weight (nPCR g/kg body wt/day), by means of a formula from Gotch and Sargent[23]: 2.03 $\Delta C + 0.16$, where ΔC is the change in BUN during dialysis ($\Delta C = C_0 - C_t$, where $C_0 =$ predialysis BUN and $C_t =$ postdialysis BUN, mg/ml) that in steady-state is equal to the interdialytic rise in BUN. This equation is based on the assumption that C_0 is constant if both urea generation (ΔC) and dose of dialysis (K_t/V) remain constant.

Statistical analysis

Values are given as mean ±SD. Analysis of variance and Bonferroni post-hoc test were used for the comparison among the three different BMI group. A $P < 0.05$ was considered significant. Pearson χ^2 test was used to compare prevalence among groups.

Results

Patients included in the study were divided into three groups on the basis of the BMI value: 47 patients were normoweight (31%), while 56 were overweight (37%), and 48 were obese (32%).

Body composition data are reported in Table 1. BCM (kg) was significantly increased in the overweight and obese groups in comparison with the normoweight group ($P<0.001$), but, of note, no significant difference was found between the obese and the overweight groups. In the obese patients there was a major increase of adipose tissue, as indicated by the high fat mass and the fractional fat mass. Interestingly, we observed a parallel increase of the Phase Angle in overweight ($P<0.05$) and obese ($P<0.05$) male patients as compared with normoweight.

Table 2 shows the nutritional intake data. In overweight and obese patients there was an increased intake of calories and proteins with a parallel increase of animal proteins and phosphate intake.

Table 3 shows dialysis data and biochemical markers of nutritional status in the three groups of patients with different BMI. Dialysis age and K_t/V values were comparable in the three groups. Total cholesterol and triglicerydes plasma levels were significantly elevated in overweight and obese patients with respect to normoweight ($P<0.05$). Serum albumin, protein catabolic rate (nPCR), serum creatinine and hematocrit were comparable in the three groups, whereas BUN and phosphate levels were higher in obese patients. These values are considered in the optimal range for well-dialyzed patients. The comparison between the two values of protein intake obtained from dietary interviews or from the nPCR, measured by urea kinetic modelling, shows a higher intake from the data obtained by the dietician. This finding is not surprising, since the protein intake derived from the urea kinetic modelling was normalized by the actual body weight, whereas that derived by the dietician was divided by the ideal body weight. At difference with the dietetic interview or the food records, that obtain information that cover several days or a week,[24] the PCR measurements vary from one dialysis session to another. For these reasons we believe that food records or dietary interviews, made by an expert dietician, are more reliable than the PCR measurements to determine long-term dietary protein. Furthermore, few reports describe an underestimate of PCR as compared to dietary records of protein intake.[25,26]

The frequency distribution of diabetes, hypertension and of smoking habit, for BMI categories is given in Fig. 1. The prevalence of hypertension and smoking was similar in the three groups, and was respectively around 50% and 40%, the presence of diabetes was increased in the obese group even if not significantly.

Within the groups of BMI, there was a greater percentage of patients with elevated plasma levels

Table 1 Anthropometric and bioimpedance analysis (BIA) data in hemodialyzed patients grouped according to BMI.

Gender	NW $n=47$		OW $n=56$		OB $n=48$	
	F, 13	M, 34	F, 18	M, 38	F, 23	M, 25
Age (years)	37.7±9.3	52.9±12.5	43.8±13.7	46.8±11.7	43.7±11.3	49.0±10.7
BW (kg)	53.5±5.5	63.5±7.3	65.2±5.4*	75.9±7.5	83.5±16.3*,†	95.9±9.0
IBW (kg)	55.6±4.9	64.3±5.5	57.4±2.9	67.5±5.0	58.4±5.5	66.8±3.9
BMI (kg/m^2)	21.6±1.8	22.7±1.4	27.5±1.8*	27.4±1.6*	35.3±5.2*,†	34.5±3.0*,†
Phase Angle (deg)	5.9±0.8	6.1±1.1	6.3±0.9	6.8±1.4*	6.4±1.3	6.8±1.2*
ECW%	46.0±3.6	46.3±5.7	44.9±4.4	42.3±5.9*	44.6±5.1	42.6±4.7*
FFM-BIA (kg)	39.9±2.3	50.4±6.3	41.9±3.6	56.3±8.8*	48.1±7.7*,†	64.6±9.4*,†
FFM-BIA %	75.0±6.0	78.8±8.5	64.5±6.5*	74.8±6.0*	57.4±6.0*,†	66.3±4.7*,†
FM-BIA (kg)	13.6±4.3	13.1±5.3	23.4±5.5*	18.8±4.4*	33.9±9.5*,†	32.4±5.7*,†
FM-BIA %	24.9±6.0	20.4±7.3	35.5±6.5*	24.4±5.3*	42.0±5.2*,†	33.7±4.7*,†
BCM-BIA (kg)	21.3±3.4	25.8±6.1	23.9±5.3	31.8±6.9*	28.4±8.4*	33.7±4.7*
BCM-BIA %	40.5±9.4	41.7±9.3	37.9±10.8	41.9±8.4	35.6±6.9	35.8±7.8*,†
IDWG (% BW)	2.5±0.8	3.3±0.7	2.9±0.6	3.1±0.9	3.7±0.8*,†	3.9±1.3†

NW, normoweight; OW, overweight; OB, obese; F, female; M, male; BW, body weight; IBW. ideal body weight; BMI, body mass index; ECW, extra-cellular water; FFM, fat-free mass; FM, fat mass; BCM, body cell mass, IDWG, inter-dialysis weight gain.
*$P<0.05$ vs. NW.
†$P<0.05$ vs. OW.

Table 2 Mean dietary intake based on interviewer-administered questionnaire in hemodialyzed patients grouped according to BMI.

	NW $n=47$	OW $n=56$	OB $n=48$
Energy (kcal/kg*)	34.7±9.1	36.8±8.9	41.4±9.7†,‡
Total protein (g/kg*)	1.26±0.3	1.36±0.3	1.61±0.4†,‡
Animal, % total protein	56.1±9.3	55.5±7.3	58.7±13.2
Total protein, % energy	14.6±2.3	14.5±1.6	15.6±2.2†
Total carbohydrate, % energy	51.0±5.0	50.6±5.9	49.1±8.1
Total fat, % energy	31.9±4.9	32.1±5.6	32.1±7.1
Saturated fat % energy	8.3±1.8	8.2±1.4	8.9±2.9
Polyunsatured fat % energy	2.7±1.3	2.6±0.9	2.68±1.2
Dietary fiber (g/day)	19.6±5.3	20.6±6.1	22.8±6.3†
Calcium (mg/day)	641±211	716±312	825±335†
Phosphorus (mg/day)	1125±327	1240±411	1355±341†
Alcohol, % energy	2.7±4.1	2.5±3.5	3.7±5.4

NW, normoweight; OW, overweight; OB, obese.
*kg, ideal weight.
†$P<0.05$ vs. NW.
‡$P<0.05$ vs. OW.

Table 3 Dialysis, biochemical and nutritional data in hemodialyzed patients ($n=151$) grouped according to BMI.

	NW $n=47$	OW $n=56$	OB $n=48$
K_t/V	1.0±0.2	1.1±0.3	1.1±0.3
Dialysis age (months)	43±25	37±24	38±23
BUN (mg/dl)	76.3±23.3	82.6±15.8	87.7±19.3*
Hematocrit (%)	33.6±3.5	32.8±2.9	32.4±3.4
Creatinine (mg/dl)	10.4±2.9	10.3±2.4	11.0±2.2
Albumin (g/dl)	4.0±0.3	3.9±0.3	3.9±0.4
NPCR (g/kg/day)	1.1±0.3	1.2±0.3	1.2±0.4
Total cholesterol (mg/dl)	165.1±42.9	183.3±45.1*	203.9±44.8*,†
HDL-Cholesterol (mg/dl)	41.3±6.7	40.7±7.4*	38.0±8.8*
Triglycerides (mg/dl)	165.5±109.7	225.6±143.3	301.6±178.5*,†
Calcium (mg/dl)	9.4±0.9	9.4±0.8	9.4±0.7
Phosphorus (mg/dl)	5.1±1.5	5.9±1.7*	5.8±1.5
Calcium × phosphorus	50.4±16.3	55.9±17.6	55.6±16.8

NW, normoweight; OW, overweight; OB, obese; PCR, protein catabolic rate; BUN, blood urea nitrogen.
*$P<0.05$ vs. NW.
†$P<0.05$ vs. OW.

of total cholesterol (⩾240 mg/dl) and triglycerides (⩾200 mg/dl), with a significant trend only for the triglycerides (Fig. 2).

Of the 151 patients screened, 9% (6F and 8M) had elevated total cholesterol (⩾240 mg/dl), 10% (4F and 11M) had low high-density lipoprotein cholesterol (HDL-Col) levels (<45 mg/dl), 39% (18F and 41M) had elevated triglycerides (⩾200 mg/dl), 9% (5F and 8M) had both elevated total cholesterol and elevated triglycerides, and 48% were hypertensive (systolic blood pressure 140 and/ or diastolic blood pressure ⩾90 mmHg or under hypertensive medication); 34% were smokers, 8.4% were diabetic on insulin treatment.

Discussion

Renal transplantation is nowadays widely recognized as the treatment of choice for end-stage renal disease. Transplanted patients, in fact, have

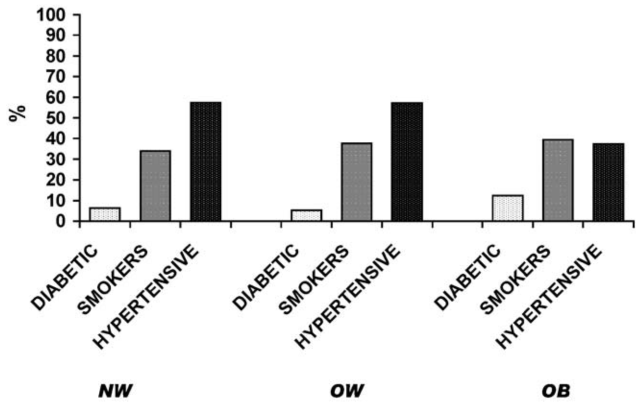

Figure 1 Percentage of diabetic on insulin treatment, smokers and hypertensive patients across BMI categories.

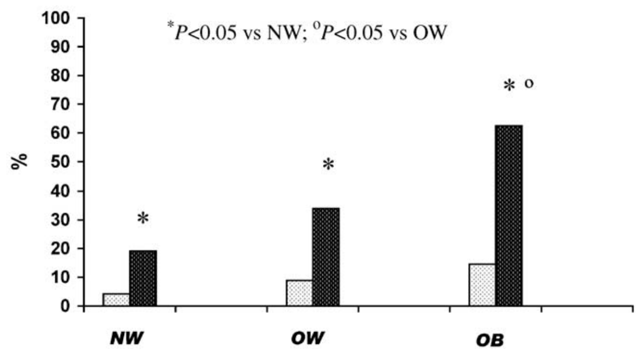

Figure 2 Percentage of patients with elevated total cholesterol □ (⩾240 mg/dl) and elevated triglycerides ■ (⩾200 mg/dl) plasma levels across the BMI categories.

a better survival as compared with patients treated with dialysis or even with those included in a waiting list for transplantation.[27] A successful transplant induces a more favorable quality of life adjustment when compared with other modalities of treatment of renal failure: hemodialysis and continuous ambulatory peritoneal dialysis.[28] An appropriate patients selection, however, is a critical factor for the long-term survival of transplanted patients. The present study shows that a large proportion of patients selected to receive a renal transplant are overweight or obese and a consistent part of them have other cardiovascular risk factors.

The prevalence of obesity is rising to epidemic proportions around the world at an alarming rate. This is relatively common in Europe, especially among women and in Southern and Eastern European countries. Current prevalence data from individual national studies suggest that the range of obesity in European countries varies from 10% to 20% for men, and 10% to 25% for women, whereas in Italy is 9.1% for both men and women and overweight prevalence is 48% for men and 25.7% for women.[29] It is of interest that this investigation, in hemodialysis patients awaiting to be transplanted, shows a prevalence of obesity (32%) even higher than that observed in the general population. These data are in agreement with recent findings, obtained in the United States, showing that two-thirds of patients at time of transplantation can be classified as overweight or obese.[30] Several potential factors may account for this phenomenon: first, the incident end stage renal disease (ESRD) population has experienced a similar rising trend in BMI;[31] in fact patients subgroups at increased risk for chronic kidney disease (e.g., diabetic, blacks, older) are also those with high prevalence of obesity. Second, it is very likely that this increase is only apparent, being the consequence of the selection criteria used for transplantation with patients underweight or malnourished being excluded as candidates for renal transplant.

The BMI distribution in patients evaluated in the present study is not representative of the entire ESRD population. In fact, there is a large body of evidence in the literature that has shown that uremia and maintenance dialysis itself are powerful promoters of protein-energy malnutrition (PEM). Several studies have shown a different prevalence of PEM in dialysis population that varies from 26% to 76% of patients, depending on age, comorbidity, case-mix, or the dose and quality of dialysis delivered.[32,33]

Wasting in HD patients may be determined by multiple factors such as reduced food intake due to anorexia, hormonal derangement, and altered protein and energy metabolism that altogether may induce a hypercatabolic state. Several recent reports have focused on the association between malnutrition, inflammation and cardiovascular disease that are frequently present at the same time in dialysis patients.[34] Measures of PEM and inflammation are major predictors of clinical outcome in dialysis patients.[35,36] A lower protein intake and a higher prevalence of malnutrition and hypoalbuminemia has been demonstrated in HD patients with cardiovascular disease (CVD) as compared to patients without CVD.[36,34] Similarly, an elevated level of serum C-Reactive Protein, a very sensitive marker of systemic inflammation, or a high production of proinflammatory cytokines have been identified as significant independent predictors of mortality in dialysis patients.[34,37–39] However, it is not completely clear how cardiac disease, inflammation and PEM in dialysis patients are interrelated.[40] It has been suggested that inflammation is the common link among these conditions.[36,41–44] In fact the activation of inflammatory cytokines (IL-6, TNFa) or their increased release, associated with uremia or with the dialysis procedure, may induce anorexia, cause muscle proteolysis and hypoalbuminemia, and is involved in the processes that result in atherosclerotic CVD.[34,42,45] This chain of events, that is primed by proinflammatory cytokines, has been named by Stenvinkel et al. malnutrition-inflammation-atherosclerosis (MIA) syndrome.[45]

Patients with full or partial MIA syndrome undergoing maintenance dialysis, are extremely fragile and have high mortality rate, therefore it is very likely that they are not included in the waiting list for transplantation. This has been partially confirmed by a study of demographics of all patients that received kidney transplant in United States since 1987,[30] that has shown that the proportion of recipients with lower BMI has fallen by approximately 50%. This phenomenon may explain the discrepancy between the BMI distribution observed in our study and that obtained in the general hemodialysis population.

BMI has been widely used as a measure for grading the overweight either in the general population or in ESRD patients, however, this parameter cannot differentiate if a weight change is due to the variation of fat mass, muscle mass or water. For this reason we performed the analysis of body composition in our population with the BIA technique.

When we compared the body composition of obese with overweight patients, we observed a significantly increased FM, whereas BCM (kg) was unchanged (Table 1). In most non-uremic obese individuals the increment of FM is associated with a parallel increase of BCM, each change accounting for almost half of the excess weight;[46] similarly, non-uremic individuals undergoing intentional overfeeding show a proportional increment of FFM and FM.[47] In a previous study by our group, in older HD patients, BCM was significantly decreased as compared to healthy subjects, and in obese patients BCM was lower than in normoweight HD patients.[48] The increased nutrient intake observed in HD obese patients (Table 2) was not associated with a significant change in BCM (Table 1), but correlated only with the increased FM. Previous studies have shown that pre-dialysis patients have significantly higher BCM and FFM as compared with hemodialysis and transplant patients[49] and that body FM increases significantly in the first year of maintenance hemodialysis.[50] Survival analyses in the general population, showed that total mortality is a linear increasing function of high FM and low FFM.[51] Also in dialysis patients a reduced FFM has been correlated with high mortality.[52] The present data indicate that HD obese patients show a partial inability to form body cell mass. It is interesting to note that also the excessive adipose tissue may be a site of production of inflammatory cytokines (IL-6, TNFa), this may explain the impaired accrual of BCM in obese HD patients.[53,54] Another possible explanation for this phenomenon may be the inadequate physical activity, which is very common in dialysis patients[55] and is eventually more marked in obese HD patients. Inactivity may exert a greater influence on protein metabolism and muscle atrophy in uremic patients as compared to subjects with normal renal function.

Nutritional intake, on the average, was adequate or high in all three groups studied, according to current guidelines for nutrition in dialysis patients.[56] However, although food intake (i.e., energy, total protein, carbohydrate, fat and phosphorus) was high in obese patients, with a protein intake of 1.6 g/kg/IBW (Table 2), this did not seem to be influential on body composition or serum albumin of obese patients when compared with the other groups studied. Furthermore, the high food intake resulted in an altered lipid profile (lower plasma HDL-cholesterol, significantly increased total cholesterol and triglycerides), a greater prevalence of diabetes and increased phosphate plasma levels (Figs. 1 and 2). Block et al. have recently highlighted the role of hyperphosphatemia as a risk factor for tissue calcification and increased cardiovascular mortality in HD patients.[57]

Several studies have shown a significant inverse relationship between mortality risk and BMI in HD populations.[58,59] The explanation for this marked difference in mortality risk related to BMI in HD population versus the general population is not known. Our data demonstrate that the increased body weight in obese patients is mainly due to FM accrual, suggesting that some of the benefits of high BMI in HD patients may be due to the increased energy reserve. This energy availability associated with the high protein intake observed in these patients may represent a defense for obese HD patients against the catabolic insults that they have to face and may explain their survival advantage.

In contrast with previous studies that have shown that being obese has a detrimental effect on both patient and allograft outcome, a recent investigation has indicated[60] that when patients with significant cardiovascular disease are excluded by careful screening, obese renal transplant patients reach long-term survivals that are comparable with their non obese counterparts. Furthermore, Glanton et al.[61] have recently shown that obese patients on the renal transplant waiting list have a lower risk of mortality after renal transplantation compared with those remaining on dialysis. This survival benefit of renal transplantation did not apply to patients with BMI$\geqslant$41 kg/m^2. These results confirm that cardiovascular disease is the most common cause of death in obese ESRD patients, with a rate of cardiovascular death among patients remaining on the waiting list that is higher than that of the kidney transplant recipients. In order to define the proper risk profile of the obese renal transplant recipient, future studies are needed to evaluate the long-term survival for different subgroups of obese patients (e.g., moderate versus severe obesity, different type or degree of comorbities associated with obesity).

This study demonstrates that the majority of patients included in the waiting list for renal transplant are overweight or obese and have other cardiovascular risk factors associated. However, since after renal transplantation, patients are exposed to an increasing number of risk factors such as further gain in adiposity, a worsening lipid profile, higher risk for diabetes and hypertension, it seems wise to undertake all the preventive strategies that would ameliorate the life expectancy of both: patients undergoing renal transplant and patients remaining on HD treatment. This approach would include the correction of the metabolic abnormalities, avoid smoking, increase physical activity, and obtain a strict control of diabetes.

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