Body composition, fitness score and arterial stiffness assesment in a chronic hemodialysis population

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Abstract

Patients undergoing long-term hemodialysis have a high risk of cardiovascular disease. Arterial stiffness is highly prevalent in this type of patients. The *aim* of our study was to analyse the relationship between body composition, blood chemistries and arterial stiffness in a poorly fit population of chronic hemodialysed patients. *Patients and methods* involved measuring body composition and fitness score by multifrequence bioimpedance with the body composition analyzer InBody720 and arterial stiffness by the measurement of aortic Pulse Wave Velocity (PWVao) and Aortic Augmentation Index (Aix) using an oscillometric method on 65 HD patients; measurements were made before a midweek dialysis session. *Results:* PWVao correlated significantly with weight ($p=0.01$, $r^2=1.14$), body fat mass ($p=0.007$, $r^2=0.14$), abdominal circumference ($p=0.01$, $r^2=0.12$) and with fitness score ($p=0.01$, $r^2=0.11$). Aix correlated with weight ($p<0.05$, $r^2=0.25$), intracellular, extracellular- and total body water ($p<0.05$, $r^2=0.24$) with body protein, soft lean mass, minerals, fat free mass and skeletal muscle mass ($p<0.05$, $r^2=0.3$) and with serum calcium ($p=0.005$, $r^2=0.2$). *Conclusions:* Arterial stiffness is a common feature of the hemodialysed patients, significantly related to the blood calcium, fitness score and the body composition, especially fat body mass.

Key words*: arterial stiffness, body composition, hemodialysis, bioimpedance, end-stage renal disease, cardiovascular risk.*

Rezumat

Pacienții aflați în program cronic de hemodializă au un risc crescut de boli cardiovasculare. Pierderea elasticității arterelor (stiffness arterial) este des întâlnită la acest tip de pacienți. *Scopul* studiului este de a evalua relația existentă între compoziția corporală, stiffness-ul arterial şi constantele biologice într-o populație de pacienți hemodializați cronic, sedentari. *Metoda* a implicat măsurarea compoziției corporale şi a scorului de fitness prin bioimpedanță multifrecvență, a elasticității arteriale prin măsurarea vitezei undei de puls aortice (PWVao) şi a indexului de augmentare aortică (Aix) prin metoda oscilometrică la 65 de pacienți hemodializați; măsurătorile au fost făcute predialitic, înainte de a doua dializă din saptamână. *Rezultate:* PWVao s-a

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corelat semnificativ cu greutatea (p=0,01, r^2=1,14), grăsimea corporală (p=0,007, r^2=0,14), circumferința abdominală (p=0,01, r^2=0,12) şi cu scorul de fitness (p=0,01, r^2=0,11). Aix s-a corelat cu greutatea (p<0,05, r^2=0,25), apa intracelulară, extracelulară şi totală (p<0,05, r^2=0,24) cu conținutul corporal de proteine, masa slabă, minerale totale, muşchi striați scheletici (p<0,05, r^2=0,3) şi cu calciul seric (p=0,005, r^2=0,2). *Concluzii*: stiffness-ul arterial, caracteristică frecventă a pacienților hemodializați, se corelează semnificativ cu valorile calciului seric, cu scorul de fitness şi cu compoziția corporală (în special conținutul de grăsime) a acestor pacienți.

Cuvinte cheie: *stiffness arterial, elasticitatea arterelor, hemodializă, bioimpedanță, boala cronică de rinichi, risc cardio-vascular.*

Introduction

The patients with end stage renal disease (ESRD) have a high risk of cardiovascular disease. Apart from other well-known cardiovascular risk factors (age, hypertension, hypercholesterolemia, diabetes), arterial stiffness plays an important and independent part in the cardiovascular prognostic of hemodialysed (HD) patients. [1,2] Non-invasive measurements of arterial stiffness that have been proven useful in HD patients include pulse wave velocity (PWV) and augmentation index (AI) of the aorta, central pulse pressure (CnPP) and carotid-brachial pulse pressure amplification (AMP). [3]

In terms of body size and body composition, the results of a study performed on more than 70.000 HD patients in United States of America showed a direct correlation between high body mass index (BMI) due to increased body fat and cardiovascular and all-cause mortality. High BMI is protective in HD patients only when it is caused by high muscular mass. [4] Moreover, losing weight while gaining muscle mass has a positive effect on the survival in long-term HD population. [5]

In our cross-sectional study, we intended to analyse the relationship between body composition and arterial stiffness in a sedentary HD population.

Patients and Method

We extracted, refined and analysed data from all the patients who undergo chronic hemodialysis 4 hours/session, 3 times/week in a private dialysis unit in Timisoara, Romania (B/Braun Avitum Dialysis Centre) on November 2011. We included in the study a number of 65 subjects consisting of all the patients who signed the written consent and were able to stand for at least 5 minutes (as requested by the bioimpedance measurements). Patients with amputee limbs were excluded. The protocol was approved by the local ethics committee.

Body composition was evaluated by multifrequence bioimpedance (frequency from 1kHz to 1MHz, using reactance analysis method) with the body composition analyzer InBody720 (Biospace Co. Ltd. Korea). There were measured parameters such as: height, weight, soft lean mass (SLM), waist-to-hip ratio (WHR), bone mineral content (BMC), intracellular/ extracellular/ total body water (ICW/ECW/TBW), striate muscle mass (SMM), visceral fat area (VFA), fat free mass (FFM), body fat mass (BFM), protein content of the body (Pr), basal metabolic rate and the fitness score.

Arterial stiffness was assessed by the measurement of aortic Pulse Wave Velocity (PWVao), Aortic Augmentation Index (Aix), aortic systolic blood pressure (SBPao), median arterial pressure (MAP) and pulse pressure (PP) using an oscillometric method (Tensiomed Arteriograph, Medexpert Ltd., Hungary).

All the measurements (body composition and arterial stiffness) were taken before a midweek dialysis session, by the same operator. Data from the literature stress the fact that, although PWV is modified by the dialysis, a high pre-dialysis PWV is unlikely to be normalized post-dialysis. [6]

Patients fitness score was assessed by the InBody analyser software, based on the subject's gender, age and body composition. Daily physical activity of the patients was recorded with digital pedometers (Omron, Nederland) and subjectively evaluated by patients as a response to a simple questionnaire.

Blood chemistries consisted of predialysis haemoglobin (Hgb), serum calcium (Ca), serum phosphates (Po), serum albumin (Alb), C reactive protein (CRP) and monthly Kt/V (urea clearance, measure of dialysis adequacy) and were recorded one week before the other measurements .

Statistical analysis: data are expressed as mean +/- SD. The relationship between the measured variables was evaluated by linear regression, performed with GraphPad Prism version 5 software. A p value <0.05 was considered necessary for establishing statistical significance between differences.

Results

We enrolled 65 patients (60% male) with the mean age of 56.8 ±9.5 years (range 30-84 years) who had been on dialysis (dialysis vintage) for 4,7 ± 4,6 (0.3-20,8) years. Most of the patients had a low level physical activity (between ~ 2000-5000 steps/day) and a mean fitness score of 69±10 (range 46-91)

The main characteristics of the study population are shown in Table I.

Table I. Clinical, bioclinical, hemodynamic and body composition characteristics of the study population (N=65)

Parameter	Value	Parameter	Value
Age (years)	56.8 ±9.5	WHR	0.96±0.07
Sex (males/female)	39/26	Percent of body fat (%)	31.3±11.5
Dialysis vintage (years)	4.7±4.6	Soft lean mass (Kg)	51.2±10.6
Weight (kg)	79.7±18.2	Fat free mass (kg)	53.7±10.8
Body mass index (kg/m2)	29.1±5.6	Body mineral content (kg)	3.6±0.7
iPTH (pg/mL)	658.1±619.4	Osseus mineral (kg)	3±0.6
Calcium (mg/dL)	8.3±0.6	PWVao(m/s)	9.5±1.5
Phosphorus (mgl/dL)	4.8±1.3	Aix aortic (%)	41.3±13.6
C-reactive protein (mg/L)	11.3±18.3	PP (mmHg)	56.7±12.7
Albumin (g/L)	37.1±2.9	SBPAo (mmHg)	149.6±20.7
Kt/V	1.2±0.1	MAP (mmHg)	108.8±14.1
Obesity degree (%)	133.5±25.9	Fitness score	69±10

Data are presented as percentage or mean ± SD; iPTH: intact parathyroid hormone; WHR: waist-to-hip ratio; PP: pulse pressure; SBPao: systolic blood pressure of aorta; MAP: medial arterial pressure.

85.7% of the patients had an arterial-venous fistula as a vascular access and 97% of them were dialysed with high flux polysulphone filters (B/Braun Diacap HIPS).

Using regression analysis we found a significant positive correlation between gender (male) and body water (ECW, ICW, TBW), soft lean mass , mineral and fat free mass ($p<0.001$, $r^2=0.3$) but no correlation between gender and body fat or BMI.

Age correlated only with PP ($p<0.001$, $r^2=0.3$) and with WHR ($p=0.03$, $r^2=0.13$)

PWVao correlated significantly with weight ($p=0.01$, $r^2=1.14$), BFM ($p=0.007$, $r^2=0,14$), abdominal circumference ($p=0.01$, $r^2=0,12$) and with fitness score ($p=0.01$, $r^2=0.11$). (Figure 1,2)

Aix correlated with weight ($p<0.05$, $r^2=0.25$), ICW, ECW, TBW ($p<0.05$, $r^2=0,24$) with body protein, SLM, minerals, FFM and SMM ($p<0.05$, $r^2= 0.3$) and with serum calcium ($p=0.005$, $r^2=0.2$). (Figure 3,4)

Blood chemistries regression analysis revealed a positive correlation between albuminemia and haemoglobin levels ($p<0.001$, $r^2=0.2$), but no statistical significant relationship among serum albumin and calcium, phosphorus, CRP, Kt/V or dialysis vintage.

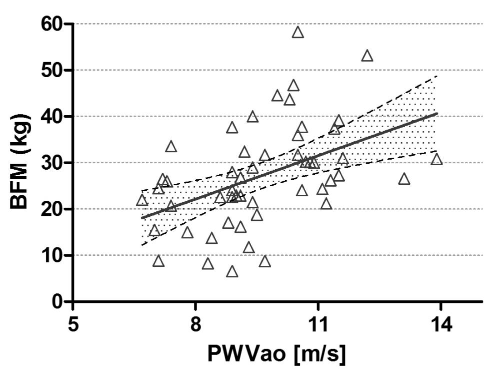

Figure 1. Linear regression of BFM and PWVao

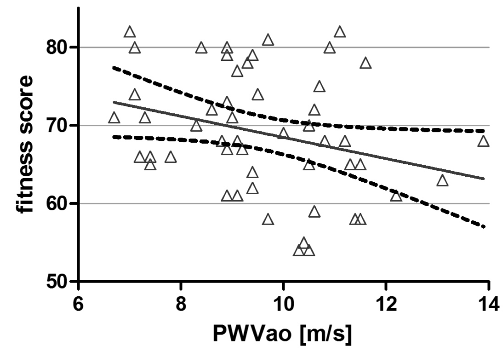

Figure 2. Linear regression of fitness score and PWVao

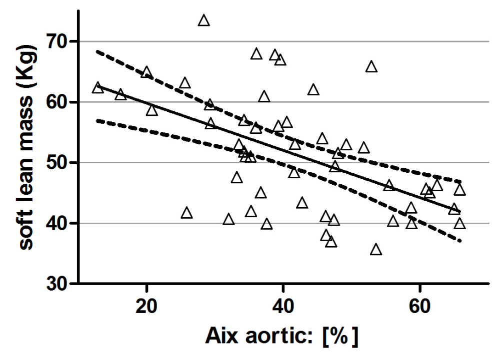

Figure 3. Linear regression of Soft lean mass and Aortic augmentation index

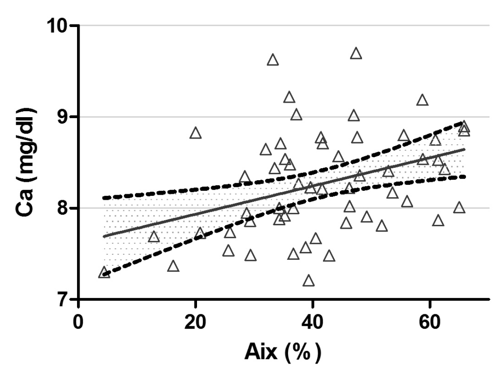

Figure 4. Linear regression of Serum calcium and Aortic augmentation index

Systolic blood pressure in Aorta (SBPao) correlated with oedema score, calculated as extracellular water/ total body water ($p<0.05$, $r^2=0.14$) and with Aix ($p<0.05$, $r^2=0.2$)

Discussions

The results of our study show that there is a correlation between HD patients' body composition and their arterial stiffness. The study population was relatively young, with a good control over pulse and blood pressure, anaemia, calcium-phosphorus disequilibrium and malnutrition (with albuminemia as a marker). Dialysis adequacy is obtained and most of the patients are dialysed with high-flux filters that enhance the middle molecules elimination.

Directly related to the measurements timing (before HD session), SBPao is determined by the fluid excess (oedema score) and by the aortic stiffness (Aix), results which are consistent with the literature data.

The patients are obese, with a high percentage of body fat (normally 10-28%, depending on gender) and not physically fit (normal fitness score for the average, reasonably healthy person starts at 80, increasing with fitness capacity). Although obesity is a cardiovascular risk factor for the general population, a phenomenon called "obesity paradox" or "reverse epidemiology" applies for the HD patients. [5,7,8] This concept refers to the fact that obese dialysis patients have a better survival than the patients with low BMI. This phenomenon was also observed in other populations: chronic heart failure, geriatric, malignancies, AIDS. [5] When the relationship between body composition modifications and mortality was analysed, results showed an increase in mortality with weight or even fat mass reduction but a better survival when muscle mass or weight was gained. [5]

Our results show an increase in PWV (pathological when >12m/s in healthy individuals) in high body fat mass patients with low fitness score, meaning that aortic stiffness is more present in the sedentary hemodialysed population. [9] There are no reference values for Aix aortic, but a previous study in HD patients found mean values of 27.9±11.9% to be significantly higher than matched hypertensive patients with normal renal function (16.5±17%, $P<0.05$). [10]

Aix aortic, a measure of the endothelial dysfunction and stiffness of the aorta, negatively correlated with SLM, fat free mass and with the protein and mineral content of the body meaning that patients with muscular wasting are more prone to arterial stiffness. Aix positive correlation with serum calcium emphasises the importance of direct high calcium effect on the vessels elasticity in the hemodialysed population by transformation of vascular smooth muscle cells into osteoblast-like cells and vessel wall calcification, a process specific for the mineral and bone disorder related to ESRD. [11]

Both measured parameters of arterial stiffness (PWV an Aix) were modified in our study population to a various extent, which proves that hemodialysed patients are at increased risk of cardiovascular disease. Positive correlation with the body fat mass and negative correlation with the soft lean mass is consistent with the literature findings that obesity is an independent risk factor for arterial stiffness.[12]

There are no clear-cut explained mechanisms for the mentioned relationship, some of the pathways by which fat mass is associated with arterial lost of elasticity might involve the release of proinflamatory citokines and leptin that were proven to have a role in endothelial dysfunction and atherogenesis. [12]

We found no significant relationship between dialysis vintage and body composition or arterial stiffness parameters. A possible explanation could be the good nutritional status of the studied patients and, as the arterial stiffness process begins at the early stages of chronic kidney disease and virtually all of the study population is affected, probably the high-flux high-efficiency dialysis has its role in slowing the progression of the artery stiffness process.

The originality of our study consists of the extensive and accurate measurements of the body composition by multifrequence bioimpedance - the gold standard in body analysis in hemodyalised patients and the correlation made with multiple markers of arterial stiffness obtained with an oscillometric method.

The weakness of our study resides in its cross-sectional design with no possibility of analysing the effect of body composition modification on the arterial stiffness, the relatively low number of studied patients and the lack of matched-control group.

Conclusions

Arterial stiffness is a common feature of the hemodialysed patients, significantly related with the blood calcium and the body composition, especially fat body mass. An optimal treatment of HD patients should include methods of muscle mass growth (physical exercise, aerobic training etc). Further studies to analyse the direct effect of body composition changes and fitness score improvement on arterial stiffness evolution in HD patients are needed.

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