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Nadciśnienie tętnicze i „sucha masa ciała" u pacjentów hemodializowanych

Hypertension and dry weight in hemodialyzed patients

Streszczenie

Wstęp. Nadciśnienie tętnicze stanowi najczęściej występujące zaburzenie hemodynamiczne u pacjentów leczonych nerkozastępczo. Wśród ogólnych czynników powodujących nadciśnienie tętnicze najważniejszy to przewodnienie. Ocena stopnia przewodnienia, a tym samym prawidłowe określenie „suchej masy ciała," stanowi integralną składową ich leczenia. Narzędziem służącym do pomiaru nawodnienia jest metoda bioimpedancji elektrycznej.

Cel. W badaniu szacowano prawidłową masę ciała u 12 pacjentów dializowanych z nadciśnieniem tętniczym przez okres sześciu miesięcy (badania przeprowadzane były przez 3 pierwsze miesiące co 2 tygodnie, przez kolejne 3 – raz w miesiącu). Użyto do tego metody bioimpedancji elektrycznej całego ciała, jak również skali wg Wizemanna (skala kliniczna).

Materiał i metoda. W badaniu wykazano korelację istotną statystycznie pomiędzy wartością ciśnienia skurczowego a wielkością ECW przed HD wśród całej grupy hemodializowanych (r = 0,55; p = 0,001). W grupie pacjentów, u których udało się obniżyć ciśnienie tętnicze dzięki korekcie suchej masy ciała (na podstawie obliczonej wielkości ECW przy pomocy bioimpedancji elektrycznej całego ciała i klinicznej skali Wizemanna) tak, że odstawiono leki obniżające ciśnienie tętnicze wykazano również korelację istotną statystycznie pomiędzy ciśnieniem skurczowym a wielkością ECW przed HD (r = 0,40; p = 0,006).

Wnioski. Wielkość ECW mierzona przy pomocy bioimpedancji elektrycznej całego ciała przed hemodializą w celu oszacowaniu należnej masy ciała korespondowała ze skalą kliniczną wg Wizemanna i stanowiła pomocne narzędzie do oceny stanu nawodnienia. Ustalenie prawidłowej suchej masy ciała spowodowało istotną redukcję lub całkowite odstawienie leków obniżających ciśnienie tętnicze krwi.

Słowa kluczowe: „sucha masa ciała", hemodializa, przewlekła niewydolność nerek, nadciśnienie, bioimpedancja, przedział pozakomórkowy

Abstract

Introduction. Hypertension is the most frequent hemodynamic disorder in patients treated with hemodialysis therapy. Over-hydration is one of the most important risk factors leading to arterial hypertension. The assessment of over-hydration and ipso facto, correct evaluation of „dry weight" is an essential part of therapy. Electrical bioimpedance analysis is a tool used for estimating the level of hydration.

Aim. The aim of this study was to assess optimal dry weight in 12 dialyzed patients with arterial hypertension over a period of six months; Study evaluations were performed every two weeks for the first three months and once a month for the final three months of our study. The whole body bioimpedance analysis and the Wizemann Clinical Scale were used in the study.

Material and methods. Our results demonstrated a significant correlation between systolic blood pressure value and the size of extracellular space before hemodialysis in the entire group of patients (r = 0.55; p = 0.001). In the group of patients in which we were able to reduce blood pressure by obtaining optimal dry weight (the whole body electrical bioimpedance and the Wizemann Clinical Scale were used to estimate ECW sizes) to a level allowing termination of their hypotensive medicines, there was also observed a statistically significant correlation between the systolic blood pressure and the size of ECW before hemodialysis (r = 0.40; p = 0.006).

Conclusions. The size of extracellular space calculated with the use of the whole body electrical bioimpedance analysis before dialysis corresponded with the Wizemann Clinical Scale and was a valuable tool in the evaluation of hydration levels. Obtaining the correct body mass (optimal dry weight) resulted in reduction or total termination of hypertensive therapy.

Key words: dry weight, hemodialysis, chronic renal failure, hypertension, bioimpedance, extracellular compartment

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INTRODUCTION

Hypertension continues to contribute to mortality in dialyzed patients despite current improvement in the dialysis procedures [1]. Hypertension is the most frequent hemo-dynamic disorder in patients treated with hemodialysis therapy and it constitutes one of the main risk factors of coronary arterial disease, myocardial infarction and stroke. When these risk factors are combined, they are the most frequent reasons for death in the dialysis population [2].

Arterial hypertension in hemodialyzed patients is a complex problem of over-hydration (hypervolemia), disorders of the RAA system (renin-angiotensin-aldosterone system), hyperactivity of sympathetic system, vascular vasodilatation, uremic toxins (ADMA, homocysteine), genetic factors, geographic factors, erythropoietin used during treatment of anemia in hemodialyzed patients, secondary hyperparathyroidism and increased sodium intake. Arterial hypertension causes hypertrophy of the left ventricle of the heart and intensifies atheromatic changes in blood vessels. Arterial hypertension is present before hemodialysis therapy has been initiated, in about 85% – 90% of patients with chronic renal failure.

Primary etiology of renal insufficiency seems to be the most prevalent factor for patients presenting with arterial hypertension. The published data indicated that patients with glomerular nephrosclerosis have higher blood pressures than patients with interstitial nephrosclerosis [2,3]. Arterial hypertension incidences often decrease in the first few months after initiation of hemodialysis therapy in approximately 20% of patients. However, a significant percentage of hemodialysis patients have what is called 'permanent arterial hypertension'. Permanent arterial hypertension is described as "hypertension resistant to dialysis therapy" and the reasons for this phenomenon are believed to be mediated by factors other than impaired sodium and water excretion in partial functioning kidneys or via the dialysis process.

Evaluation of hydration levels in dialyzed patients is an essential part of dialysis therapy specifically because of the risk of over-hydration and its association with arterial hypertension, and/or dehydration that leads to hypotonia during dialysis [4-7]. The elimination of fluid excess during dialysis treatment is achieved with the use of ultrafiltration so that the patient reaches a weight called "optimal dry weight." Optimal dry weight is often defined as "target weight". Optimal dry weight is described as the lowest body mass which is tolerated by a patient without producing any side effects during dialysis or hypotonia at the end of the dialysis session [8]. Complications during dialysis can be caused by an imbalance between the ultrafiltration rate and the plasma refilling index [9]. The removal of fluid through ultrafiltration occurs first from the intravascular space and the central segment of the body (trunk) [10]. At the same time, fluids flow from the peripheral segments (interstitial) into the central compartment (trunk). This movement of fluid between compartments, moving from the interstitial to intravascular space (refilling), causes a change in the total blood volume in that compartment. The rate at which refilling occurs is known as the plasma refilling index in the intravascular compartment [11]. During dialysis treatment, when the ultrafiltration rate is higher than the plasma refilling index, a patient has a greater risk of occurrence of hypotonia [12].

Unfortunately, there is no current standardized method of evaluating dry weight in dialyzed patients. Therefore, it is very difficult to set an ideal ultrafiltration rate and level for each patient to decrease the risk of complications occurring during dialysis [13]. In many dialysis centers optimal dry weight is assessed by clinical examination [14]. This method while incorporating many components specific to this population, unfortunately, continues to under estimate over-hydration or dehydration in these patients. Many other techniques have been utilized to compensate or assist in the evaluation of hydration status in this population. A clinical scale of hydration assessment proposed by Wizemann takes into consideration symptoms such as over-hydration and dehydration parameters. The symptoms of over-hydration are dyspnea while resting, dyspnea while walking, edema (from mediocre to significantly intensified), and overfilling of the internal jugular veins. The dehydration symptoms are blood pressure drop during dialysis requiring a change in body position, blood pressure drop during dialysis requiring fluids administration, blood pressure drop during dialysis due to vomitting, cramps from mild to medium and severe, feeling of weakness during dialysis and increased thirst after dialysis [15].

Monitoring of hydration levels in dialyzed patients is an important clinical aspect of the quality of treatment, as stated previously. When a current method for monitoring hydration is inadequate, another method must be considered to provide increased or improved treatment quality for this patient population. As stated earlier, during dialysis the fluid is removed from the patient with the use of ultrafiltration mainly from the intravascular space. Knowledge and understanding of other fluid compartments of the body during this dynamic process can be beneficial in reducing complications associated with this therapy. Bioimpedance has been established as a valuable tool in the evaluation of hydration states of various compartment of the body in the dialyzed patient [16, 17].

The bioimpedance technique incorporates precise evaluation of hydration levels utilizing physiological data concerning the assessment of water compartment sizes, such as TBW (total body water), ECW (extracellular water), ICW (intracellular water) and interstitial compartment [18]. The specific mechanisms of this technique are based on an elementary principle that electrical resistance of a cylinder is directly proportional to the length and inversely proportional to the cross section area of the cylinder multiplied by the density. This method is based on the evaluation of electrical resistance in body tissues with the relationship to an alternating multi-frequency current [19].

Although the principal bioimpedance techniques were first introduced by Thomassett in 1963, an increased interest in this technique appeared in the early seventies of the last century when Nyboer demonstrated a correlation between bioimpedance value assessed with a use of an alternating current and changes in the blood volume [20]. Many articles described the method of the whole body bioimpedance analysis (WBIA). The WBIA method places the electrodes on the palm and foot (the wrist and ankle placement of the electrodes have also been used). An alternating current, with

frequencies from 5 to 500 kHz reaches the electrodes placed at the level of the metacarpophalangeal joint in finger III of the upper extremity and at the base of the metatarsophalangeal joint in toe II and III of the lower extremity – the voltage is measured between the electrodes placed on the wrist in an imagined line connecting the styloid process of the ulnar bone with the styloid process of the radial bone and the electrode placed in a line connecting the medial and lateral condyle. It is possible, utilizing the bioimpedance technique to choose an option of one current frequency usage or a multi-frequency option with an amplitude from a few to a few hundred (500) kHz. It should be noted that WBIA assessment is dependent on changes in body position. Therefore, body position changes must be considered when analyzing results using this method. A segmental bioimpedance technique is an assessment of independent body segments, such as upper extremities, trunk and lower extremities. The results analysis using this technique has been observed to be a more precise evaluation of hydration states and dynamical changes during dialysis sessions.

Bioimpedance technique provides a useful method to assess the size of TBW and ECW

compartments during the dialysis process. The purpose of this study was to find.

a method that would be helpful in evaluating optimal dry weight status, relatively easy and inexpensive to use and which would require minimal training of staff to facilitate maximum usage.

MATERIAL AND METHODS

The aim of this study was to assess optimal dry weight in 12 dialyzed patients with arterial hypertension over a period of six months. We were specifically observing any correlation between blood pressure values and the size of extracellular (ECW) and intracellular (ICW) space to create (if possible) a model for standardizing optimal dry weight assessment in hemodialyzed patients utilizing strict blood pressure regulation. Optimal dry weight defined in this article as the lowest body mass weight tolerated by a patient without any occurrence of side effects during dialysis or hypotonia at the end of dialysis session. Arterial hypertension is defined in this article as a mean blood pressure of 106 or higher.

The whole body bioimpedance analysis (WBIA) was used to provide a single assessment of the size of extracellular and intracellular space before hemodialysis. Study evaluations were performed on each patient every two weeks for the first three months of our study and once a month for the final three months of our study.

The Wizemann Clinical Scale was used to estimate the level of over-hydration or dehydration in our population.

The parameters of this scale are listed in Table 1 and 2.

Inclusion criteria:

- Patients diagnosed with chronic renal failure (CRF) were included in the study
- Age between 18 and 80 years
- Clinically stable
- Written consent of the patients for participation in this study

Exclusion criteria:

- Patients with mental problems
- Pregnancy or lactation patients
- Patients with amputation of a lower limb
- Patients with an implanted pacemaker
- Patient with severe hemodynamic circulatory insufficiency

Measures:

The following parameters were measured in each patient:

- Body mass before and after hemodialysis (in kg)
- Height of a patient (in cm)
- Blood pressure before hemodialysis

Anthropometric measures

- Body mass of a patient was measured with the use of the scale with an acceptable deviation of 0.1 kg
- Height of a patient (in cm without shoes) was measured with the use of a standard measure.

TABLE 1. Wizemann Clinical Scale; Over-hydration symptoms.

Symptom	Score
Dyspnea requiring sitting position	+ 6
Dyspnea, 2 pillows	+ 4
Dyspnea, 1 pillow	+ 3
Moderate dyspnea	+ 2
Chronic cough	+ 2
Intense edema	+ 3
Mediocre edema	+ 2
BP increase during ultrafiltration	+ 2
No symptoms	0
Total	

TABLE 2. Wizemann Clinical Scale; Dehydration symptoms.

Symptom	Score
BP drop during hemodialysis requiring change of position only	- 1
BP drop during hemodialysis requiring administration of concentrated solution of NaCl	- 2
BP drop during hemodialysis due to vomitting	- 8
Intense cramps during hemodialysis	- 3
Mild cramps during hemodialysis	- 2
Weakness during hemodialysis	- 3
Dizziness during hemodialysis	- 4
Increased thirst after hemodialysis	- 1
No symptoms	0
Total	

Electrical bioimpedance measurements

Bioimpedance measurements were performed with a bioimpedance analyzer (Xitron Hydra 4200 Bioimpedance spectroscopy device measuring at 50 frequencies between 5 kHz and 1 MHz) with electrodes (7.7 x 1.9 cm²). The software for this device is the fluid management tool (FMT ver. 2.0).

Study protocol

All parameters were measured at the beginning of hemodialysis. Parameters were not measured during dialysis treatment to avoid errors in the evaluation of data, as the greatest fluid distribution occurs within the first hour of hemodialysis.

Examination procedures

Patients were placed in a reclining position for 10 minutes before WBIA was performed. Bioimpedance was measured in a logarithmic spectrum of 10 frequencies starting from 5 to 500 kHz. Two electrodes inducing an alternating current were placed dorsally on the hand (I1) and ankle (I2) on the same side of the body of a patient.

Measuring electrodes were placed on the wrist (S1) and the ankle (S2) on the same side of the body of a patient. A computer was used to collect and store data from each measurement.

Statistical methods

Our results were statistically analyzed. The analysis parameters included arithmetical mean (M), standard deviation (SD) with a defined range of variability (Min – Max) and confidence interval for the mean (95% Cl). The Shapiro-Wilk (S-W) test was used to assess the distribution conformity of examined parameters with a normal distribution. The Fisher (F) test was used to assess variance homogeneity. To compare the two groups (independent samples) according to the type of distribution and variance homogeneity the Student's T-Test or the Cochrane-Cox test was used. The Student's T-test was used for dependent samples. Non-parametric equivalents of the Student's T-test were used for skewed distributions: for independent samples – the Mann-Whitney U test and for dependent samples – a pair sequence Wilcoxon's test. To assess if there was a correlation between two parameters a correlation coefficient significance test (Pearson's r or Spearman's) was used. An accepted conclusion error was 5% and connected with it statistical significance was $p < 0.05$ which would reveal the existence of statistically significant differences of correlations. The statistical analysis of this study was performed using computer software STATISTICA v.6.0 (StatSoft, Poland).

RESULTS

TABLE 3. Clinical and biochemical characteristics and state of hydration in the study group patients.

Parameter	Mean (M)	SD
Height (cm)	164.17	10.81
Age (years)	46.5	14.78
Dialysis time (months)	49.17	74.97
Kt/V	1.05	0.25
Pcr	1.93	0.47
Dry weight (kg)	62.69	12.40
Weight before HD (kg)	64.83	12.56
Weight after HD (kg)	62.57	12.36
Systolic BP before HD (mmHg)	150.83	24.78
Diastolic BP before HD (mmHg)	82.92	7.53
Pulse	73.00	8.88
ECW before HD (l)	16.88	3.83
ICW before HD (l)	17.61	5.27
Urea before HD (mg/dl)	147.84	27.94
Urea after HD (mg/dl)	52.53	15.07
Creatinine before HD (mg/dl)	8.70	2.20
Creatinine after HD (mg/dl)	3.88	1.05
Na before HD (mEq/l)	139.86	2.94
Na after HD (mEq/l)	139.10	2.49
Albumin level (g/dl)	4.05	0.66
Total protein level (g/dl)	6.73	0.66
P after HD (mg/dl)	4.29	1.04
Hct after HD (%)	30.36	4.01

In order to obtain an expected body mass (dry weight) in our study patient population, we either increased or decreased their optimal dry weight based on clinical symptoms determined by the Wizemann Scale and on the size of extracellular space calculated with the use of whole body electrical bioimpedance analysis.

Due to skewed distribution of dialysis time of our study patients (determined in months) this parameter will be described in terms of means and median, respectively. Mean treatment duration for this study group was 49.17 months and median duration was 14.5 months.

TABLE 4. Group blood pressure medication used in our study group population.

	Dose at the beginning of the study (mg)	Dose at the end of the study (mg)
Diuretics	1560	1200
Beta blockers	265	112.5
Dihydropiridine calcium channel blockers	75	62.5
Non-dihydropiridine calcium channel blockers	–	–
ACEI/ARB	152	140
Alfa blockers	20	20
CNS drugs	0.6	0.6
Direct Vasodilators	0.175	0.175

Our analysis demonstrated a statistical significant correlation between systolic and diastolic blood pressure values and the size of ECW and ICW before hemodialysis within the entire study group of patients ($r = 0.55$; $p = 0.001$). Table 8 and Figure 1. Dry weight was precisely obtained in 7 out of 12 patients in this study, which corresponded with a significant blood pressure decrease and reduction in hypertensive medicines. Decreases in dosage and class of medications are listed in Table 4 above and Figure 5 below. During analysis of our data, we divided our group of 12 patients into two subgroups, Subgroup 1 (a group of patients in which dry weight was reduced and as a consequence of weight reduction, it was possible to reduce hypertensive medicines and Subgroup 2 (a group of patients in which we were not able to assess the dry weight or adequately reduce blood pressure and therefore a reduction of hypertensive medicines was not possible).

TABLE 5. BP values with ECW and ICW in our study group patients.

Parameter	n	Mean (M)	SD	Confidence interval 95%Cl	Min – Max
Systolic BP (mmHg)	79	128.04	26.06	122.20- 133.86	80.00-195.00
Diastolic BP (mmHg)	79	74.94	11.10	72.45-77.42	50.00-100.00
ECW (l)	79	16.24	4.16	15.30-17.17	10.78-28.59
ICW (l)	79	17.52	4.70	16.47-18.57	10.73-31.33

TABLE 6. BP values with ECW and ICW in Subgroup 1 of our study group.

Parameter	N	Mean (M)	SD	Confidence interval 95%Cl	Min – Max
Systolic BP (mmHg)	47	125.32	25.16	117.93 - 132.71	80.00 - 95.00
Diastolic BP (mmHg)	47	75.64	11.06	72.39 - 78.89	50.00 - 90.00
ECW (l)	47	15.13	3.26	14.17 - 16.09	10.78 - 20.95
ICW (l)	47	18.25	5.68	16.59 - 19.92	10.73 - 31.33

TABLE 7. BP values with ECW and ICW in Subgroup 2.

Parameter	N	Mean (M)	SD	Confidence interval 95%Cl	Min – Max
Systolic BP (mmHg)	32	132.03	27.23	122.21 - 141.85	100.00 - 195.00
Diastolic BP (mmHg)	32	73.91	11.24	69.85 - 77.96	60.00 - 100.00
ECW (l)	32	17.86	4.82	16.13 - 19.60	11.88 - 28.59
ICW (l)	32	16.45	2.38	15.59 - 17.31	12.58 - 21.26

TABLE 8. The table shows statistical correlations in the whole group of patients with arterial hypertension.

N = 79	ECW before HD	ICW before HD
Systolic BP	r = 0.55;	r = 0.18;
	p = 0.001	p = 0.11
Diastolic BP	r = 0.12,	r = -0.007;
	p = 0.35	p = 0.95

ciśnienie skurczowe - systolic pressure
p.ufności - level of statistical significance

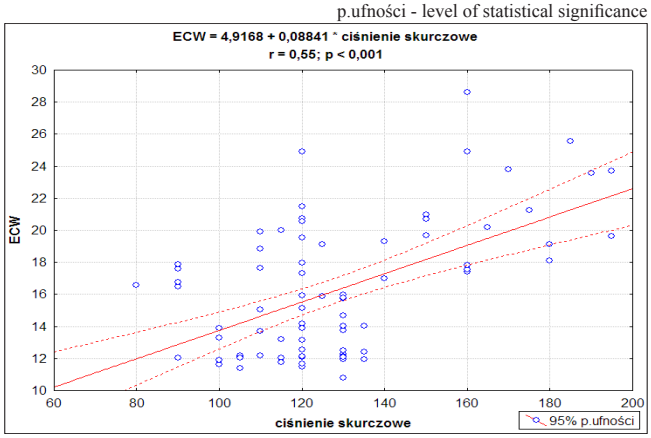


FIGURE 1. Correlation between systolic blood pressure value and the size of ECW before hemodialysis in the whole group (N = 12).

We also observed a statistically significant correlation between the systolic blood pressure and the size of ECW before hemodialysis (r = 0.40; p = 0.006) in Subgroup 1. In this group of patients we were able to either reduce blood pressure or terminate their hypotensive medicines. These results are illustrated in Table 9 and Figure 2.

TABLE 9. Table shows statistical correlations in Subgroup 1.

N = 47	ECW before HD	ICW before HD
Systolic BP	r = 0.40;	r = 0.20;
	p = 0.006	p = 0.18
Diastolic BP	r = -0.02;	r = -0.07;
	p = 0.87	p = 0.62

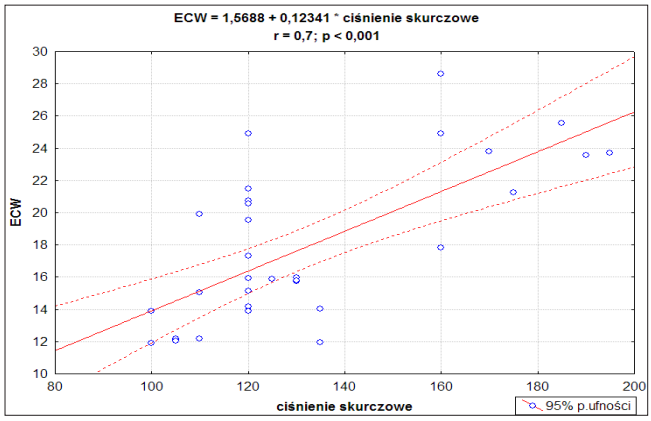


FIGURE 2. Correlation between the systolic blood pressure and the size of ECW in Subgroup 1.

We also observed a statistically significant correlation between the systolic blood pressure and the size of ECW before hemodialysis in Subgroup 2 (r = 0.70; p = 0.001). However, we failed to determine their optimal dry weight or reduce their blood pressure medicines. These results are illustrated in Table 10 and Figure 3.

TABLE 10. Statistical correlations concerning in Subgroup 2.

N = 32	ECW before HD	ICW before HD
Systolic BP	R = 0.70; p = 0.001	r = 0.31; p = 0.09
Diastolic BP	R = 0.30; p = 0.09	r = 0.15; p = 0.41

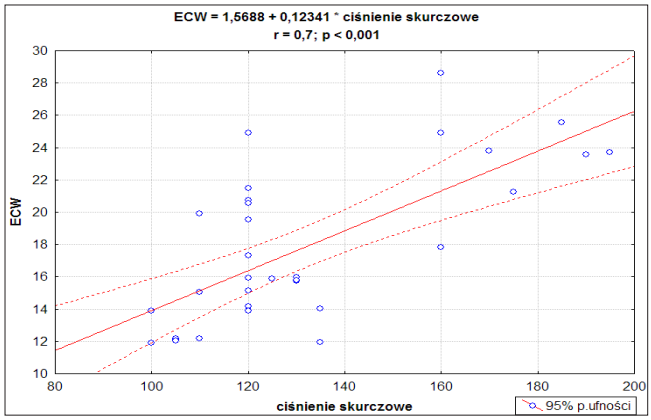


FIGURE 3. Correlation between the systolic blood pressure value and the size of ECW before hemodialysis in Subgroup 2.

We observed a statistically significant difference in ECW before hemodialysis between Subgroups 1 and 2 (t = -3.01; p = 0.004). Subgroup 2 had a higher ECW (mean ECW 17.86 ± 4.82) before hemodialysis than Subgroup 1 (mean ECW 15.3 ±3.26). These results are illustrated in Table 11 and Figures 4 and 5.

TABLE 11. Difference in ECW and ICW measured before hemodialysis in Subgroup 1 and Subgroup 2).

	ECW before HD	ICW before HD
Group 1	t=-3.01;	t=1.70
Group 2	p = 0.004	p = 0.09

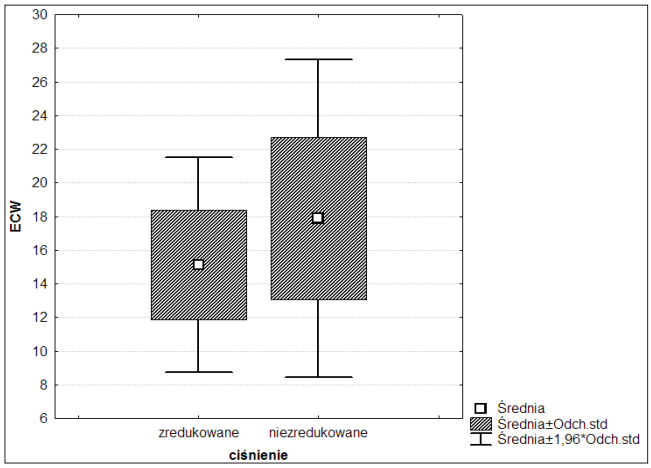
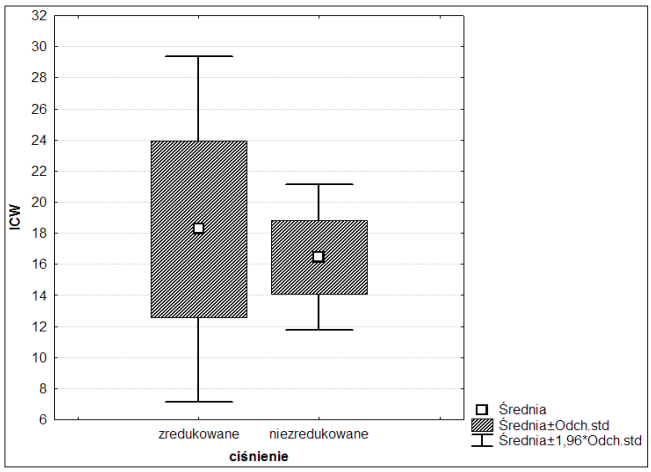


FIGURE 4. ECW measured before hemodialysis in Group 1 and in Group 2.



ciśnienie - pressure; zredukowane - reduced; niezredukowane - not reduced
Średnia - mean value; Odch.std - standard deviation

FIGURE 5. ICW measured before hemodialysis in Group 1 and Group 2.

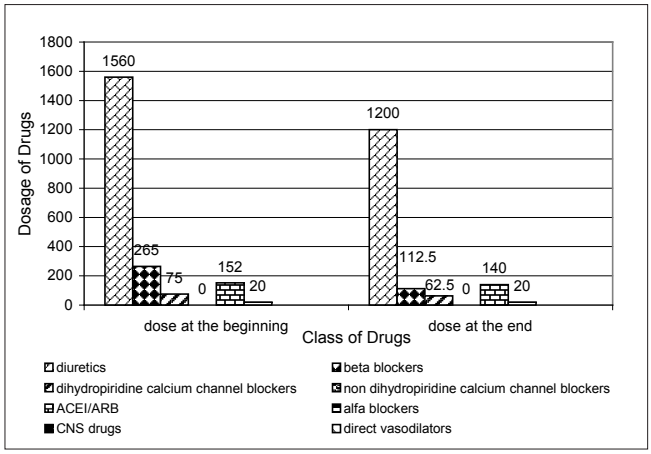


FIGURE 6. The total dose of hypotensive medicines at the beginning and at the end of the study in the whole group of examined patients (N = 12).

DISCUSSION

Arterial hypertension in approximately 80% of patients with chronic renal failure (CRF) is volume-dependent [21]. When the volume is well managed in patients, it is often possible to normalize hypertension by effective dehydration and obtaining an optimal dry weight in these patients [12, 21]. In approximately 20% of CRF patients arterial hypertension is a result of autonomic nervous system stimulation (the sympathetic system) and endocrine disorders. It has been established that sympathetic system activity plays an important role in the blood pressure regulation in patients with chronic renal insufficiency [1]. There are other CRF patients who fall outside the aforementioned categories and who are said to have hypertension resistant to dialysis therapy [2]. Many research studies have tried to identify factors associated with hypertension, as a means to control this condition. Some of these factors include, increase plasma volume, extracellular volume and sodium concentration have been observed in patients with chronic renal insufficiency [21]. Progressing impairment of renal function leads to an increased volume of extracellular fluids and intensified sodium re-absorption and causes an increase of Na+/K+-ATPase inhibitors concentration. The inhibitors suppress the function of Na+/K+-ATPase in kidneys and other tissues, in smooth muscles, in blood vessels leading to an increase of intracellular sodium ions concentration. A decreased transmembrane gradient of sodium concentrations leads to a decreased calcium elimination from the cell and, therefore an increase of calcium intracellular concentration. The result of these changes is increased vascular reactivity and contractility that lead to increased vascular tension and vascular resistance. Additionally, the suppression of Na+/K+ pump activity in nerve synapses leads to a a decreased noradrenalin re-uptake causing a prolonged activation of smooth muscles in blood vessels. The presence of Quabain-like substances intensifying the effect of Na+/K+-ATPase was revealed in the plasma of patients with chronic renal insufficiency. This is still another factor that influences the blood pressure increase by stimulating vascular resistance is PTH [23]. In patients with established dry weight, the presence of arterial hypertension can be related to increased activation of the RAA system and the sympathetic system. It is known that RAA system disorders appear in chronic renal insufficiency. The activity of this system is increased in case of changes in water compartments volumes, exchangeable sodium level, in standing position and in a situation when angiotensin II activity is suppressed. Angiotensin works also as a growth factor that induces hypertrophy of the vascular wall and increased peripheral resistance. Multiple data point to an increased level of catecholamines in patients with chronic renal insufficiency which is a result of plasma volume drop and negative sodium balance [24].

Destructive factors as a consequence of hypertension have been illuminated as well. Arterial hypertension leads to many lesions in organs. Consistent increase in blood pressure levels directly determines the degree of damages observed in organs. The European Dialysis and Transplant Association (EDTA) Trial demonstrated that in 32% of patients examined before beginning the dialysis therapy, systolic and diastolic blood pressure values were above 160 and 80 – 89 mmHg, respectively. Furthermore, a decrease in arterial hypertension was observed in this population within a few months of treatment with hemodialysis therapy [2].

It is clear that a precise evaluation of a human body structure and the state of hydration plays a significant role in

obtaining expected dry weight in CRF patients, treated with hemodialysis [25]. The assessment of water compartments is vital because is provides evaluation of the optimal hydration state. The total volume of fluid removed during dialysis should be individualized to patient undergoing this therapy in order to reach an expected "dry weight." One of the methods of measuring the state of hydration is a whole body bioimpedance technique. This technique provides as easy to use and non-invasive method of monitoring fluid compartments sizes within the body [26].

Measurements of water compartments with electrical bioimpedance combined with clinical evaluation such as the Wizemann Scale enabled us to establish the optimal body mass for the subgroup of patients with arterial hypertension. Our results demonstrated a significant correlation between the systolic blood pressure value and the size of extracellular space in the entire group of patients ($r = 0.55$; $p = 0.001$). It is noticeable that in Subgroup 2 of patients with unreduced blood pressure, the correlation between systolic BP and ECW was stronger in comparison to the group with reduced blood pressure (respectively $r = 0.70$, $p = 0.001$ and $r = 0.40$; $p = 0.006$). These results of Subgroup 2 may be due to additional factors responsible for their arterial hypertension that are independent of changes in the size of extracellular space. The central nervous system (sympathetic part) plays an important role in arterial hypertension pathogenesis. Quabain-like substances, responsible for blood pressure increase, as well as PTH, that stimulate significantly vascular resistance to increase, may also have significant influence.

We did not observe any significant correlation between the parameter of DP and ICW in this study. It is possible that these parameters play a lesser role in the hydration status per se and that changes or influences in these compartments are not readily observed. Further research in this area would be helpful in illuminating this aspect of fluid compartments and hydration.

Additional information about changes in intravascular space during dialysis procedures can be obtained by monitoring changes in the total plasma volume with the use of the BVM technique (blood volume monitoring) which when combined with bioimpedance, gives more precise understanding of water distribution in individual compartments during hemodialysis therapy [27].

However, the scope of this study was to evaluate the usefulness of bioimpedance in the evaluation of hydration status, the mention of other devices although beneficial, are included only for discussion.

CONCLUSION

Hydration status is an extremely important factor determining development of arterial hypertensionin hemodialyzed patients. The results of our study demonstrate that the whole body bioimpedance assessment (WBIA), combined with the clinical assessment of the patients are valuable tools for the evaluation of hydration state in the hemodialysis population. We observed that the size of extracellular compartments volume (ECV) measured with WBIA before hemodialysis corresponded well with the Wizemann Clinical Scale. Electrical bioimpedance method is a relatively sensitive and repeatable method to use. Correct assessment of the body mass (optimal dry weight) may result in a reduction or total termination of hypertensive therapy in this patient population.

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