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Impedance cardiography – optimization and efficacy evaluation of antihypertensive treatment

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A – Study Design, **B** – Data Collection, **C** – Statistical Analysis, **D** – Data Interpretation, **E** – Manuscript Preparation, **F** – Literature Search, **G** – Funds Collection

Summary **Background.** Hypertension is a civilization disease which currently affects about 10.5 m people in Poland. The number of patients with diagnosed, untreated hypertension amounts to 18%, and as many as 45% of patients are treated ineffectively, whereas only 26% are treated effectively. Impedance cardiography (IC) is an important tool both in diagnostics and the treatment of hypertensive patients, particularly in the case of antihypertensive treatment resistance. This method allows for the individualized treatment of each patient on the basis of hemodynamic parameters, monitoring of hypertensive patients in the outpatient care setting, and the assessment of cardiovascular risk factors.

Objectives. The aim of the study was to evaluate the efficacy of hypotensive medications in patients with hypertension using impedance cardiography.

Material and methods. The study involved 60 hypertensive patients, treated with antihypertensives, who failed to achieve the required blood pressure values. The modification of hypertension therapy was based on EBM (evidence-based medicine) and on hemodynamic parameters obtained using impedance cardiography.

Results. It was found that high blood pressure therapy based on impedance cardiography parameters has a significant influence on blood pressure reduction compared to EMB-based therapy: below 140/90: 66.8 *vs.* 55.1% and below 130/80: 23.5 *vs.* 18.9%.

Conclusions. On the basis of this study it was confirmed that impedance cardiography allows for a significant reduction of hypertension and the selection of the most effective therapeutic strategy, providing for the optimization and efficacy of hypertension treatment.

Key words: hypertension, impedance cardiography, EBM.

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Background

Hypertension is a civilization disease which currently affects about 972 m people all over the world, including 10.5 m in Poland [1–3].

In Poland, the number of patients with diagnosed, untreated hypertension amounts to 18%, and as many as 45% of patients are treated ineffectively, whereas only 26% are treated effectively. It is estimated that every year 14% of deaths in the world are caused by hypertension. Therefore, it is very important to diagnose this disease entity properly and as early as possible, and following that, to treat it effectively [3, 4].

Particular attention must be paid to the very issue of hypertension treatment, considering all its benefits while being aware and taking into account all the adverse effects of individual medications. This is of crucial importance for the optimization and efficacy of hypertension treatment [5, 6].

The new methods for monitoring the hemodynamic parameters of the cardiovascular system have recently become objects of scientific interest. Presently, impedance cardiography, IC, is used in cardiology practice, allowing for the precise evaluation of such parameters as: cardiac output, systemic vascular resistance, vascular stiffness, left ventricular ejection time [7–10].

Objectives

The aim of the study was to evaluate the efficacy of hypotensive medications in patients with hypertension using impedance cardiography.

Material and methods

The examination was performed at the "Zdrowie" GP practice in Lublin in 60 patients with hypertension. Patients with diagnosed hypertension (≥ 140/90) who were not treated before, and patients treated with one or more hypotensive drugs, who failed to achieve the required values, were qualified for the study.

The exclusion criteria were as follows: secondary hypertension, improperly controlled hypertension treated with three or more hypotensive drugs, concomitant morbidities, such as: cardiac diseases, cardiomyopathies, significant cardiac rhythm disturbance, vascular diseases, renal diseases, COPD, diabetes, polyneuropathy, peripheral vascular disease, age < 18 years and > 65 years.

The study was approved by the Bioethical Committee at the Medical University of Lublin. No. of approval: KE-0254/121/2011. All patients provided their written informed consent to participate in the study.

The study population of patients was randomly divided into two groups. The study was conducted in a randomized manner. Each group of patients included 30 subjects. The first group consisted of patients in whom the modification of hypertension treatment was based on EBM (evidence-based medicine). The second group consisted of patients in whom the modification of hypertension treatment was based on the hemodynamic parameters obtained by impedance cardiography (Table 1). The test was performed using the Icon bioimpedance analyzer, Osypka.

Table 1. Characteristics of two groups of patients

	EBM patients	IC patients	*p*
Women	18 (60% of the total number of patients)	21 (70% of the total number of patients)	0.313
Men	12 (40% of the total number of patients)	9 (30% of the total number of patients)	0.284
Age	55.2 ± 8.86	52.7 ± 9.07	0.412
BMI	26.96 ± 12.17	28.31 ± 12.26	0.298

An attending physician performed a blood pressure measurement (the mean value of 3 measurements) using Tensoval, Hartmann's upper arm blood pressure monitor.

Impedance cardiography examination was performed 3 times: on the first appointment, after one month, and after two months since the first appointment.

For the evaluation of hypertension treatment efficacy, as well as its modification, the following parameters were employed [1]: CI (cardiac index) for hyperdynamic profile, where CI > 4,2 L/min/m^2 and/or HR > 80/min: beta blocker; SVRI (systemic vascular resistance index) for vasoconstriction profile, where SVRI > 2500 dyn · s · cm^{-5} · m^2: ACEI or ARB, at SVRI > 2800: Ca channel blocker; TFC (thoracic fluid content) for hypervolemic profile, where TFC > 34 1/kOhm for men and > 24 1/kOhm for women: diuretic.

On the first appointment the hypotensive treatment was modified based on EBM or hemodynamic data of impedance cardiography.

Medications which were used for hypotensive treatment modification were as follows [1]: ACEI: lisinopril, ARB: telmisartan, tiasis diuretic: hydrochlorothiazide, beta blocker: metoprolol, Ca channel blocker: amlodipine.

At the next two appointments the efficacy of hypotensive treatment was evaluated on the basis of RR measurements and hemodynamic parameters of impedance cardiography. Another stage involved a comparison of the results obtained in the two groups of patients.

Statistical evaluation

The obtained study results were statistically analyzed. The analysis was performed using the Statistica 10 package. For comparison of the two groups, in which the distribution was not significantly different from the normal one, statistical significance was verified using the *t*-Student test for independent samples, and the U Mann–Whitney test was used for the distributions which were significantly different from the normal one. To verify the significance of differences for time effects (3 stages of the study) in the case of normal distribution a single factor ANOVA analysis of variance was employed for repeated measures (with the Greenhouse–Geisser correction if the sphericity assumptions were not met) or multivariate ANOVA for repeated measures (the Wilks test). If the normality assumptions were not met, ANOVA Freidman's nonparametric test was used to compare time effects. The significance level was determined at $p = 0.05$.

Results

Table 2. Quantitative distribution of applied drug groups in study groups

	EBM patients	IC patients	*p*
RAA system blockers	87.2	87.8	0.998
Ca channel blockers	28.2	10.3	0.021
Diuretics	33.2	30.5	0.876
β-blockers	40.5	20.7	0.061

Table 3. Comparison of study results in two groups of patients

	EBM patients	IC patients	*p*
1st measurement			
SBP	138.3 ± 12.6	155.3 ± 7.6	0.000
DBP	79.5 ± 6.4	87.5 ± 8.3	0.000
SVRI	2539.0 ± 396.3	2791.5 ± 548.9	0.046
CI	3.2 ± 0.6	3.4 ± 0.6	0.027
HR	73.7 ± 8.4	75.9 ± 9.1	0.337
TFC	25.8 ± 5.4	27.7 ± 3.0	0.004
2nd measurement			
SBP	140.3 ± 11.4	139.3 ± 12.0	0.742
DBP	81.9 ± 8.0	83.6 ± 7.6	0.402
SVRI	2751.1 ± 593.8	2603.7 ± 446.7	0.282
CI	3.3 ± 0.5	3.2 ± 0.4	0.918
HR	73.6 ± 8.7	75.2 ± 8.2	0.252
TFC	26.8 ± 6.0	27.1 ± 2.7	0.077
3rd measurement			
SBP	134.3 ± 12.6	131.1 ± 12.0	0.018
DBP	80.0 ± 6.0	79.5 ± 6.4	0.040
SVRI	2571.4 ± 598.3	2539.0 ± 396.3	0.037
CI	3.2 ± 0.6	3.1 ± 0.4	0.712
HR	73.7 ± 8.4	73.2 ± 7.9	0.838
TFC	25.8 ± 5.4	24.4 ± 3.3	0.425

At the 0.05 level of significance a statistically significant difference was observed between SBP-1 ($p = 0.000$), DBP-1 ($p = 0.000$) and SVRI-1 ($p = 0.046$) values obtained in the EBM and IC groups.

At the 0.05 level of significance a statistically significant difference was observed between CI-1 ($p = 0.027$), TFC-1 ($p = 0.004$) values obtained in the EBM and IC groups.

At the 0.05 level of significance a statistically significant difference was observed between SBP-3 ($p = 0.018$), DBP-3 ($p = 0.040$) and SVRI-3 ($p = 0.037$) values obtained in the EBM and IC groups (Table 2–4).

Table 4. Efficacy of hypertension treatment in two groups of patients – percentage distribution

	EBM patients	IC patients	*p*
< 140/90	55.1 %	66.8 %	0.046
< 130/80	18.9 %	23.5 %	0.030

Discussion

Hypertension is one of the most common cardiovascular diseases. Previous research analyses indicate that the appropriate values of blood pressure significantly decrease the

risk of further disease progression and prevent the relevant complications. Bearing that in mind, an early diagnosis and constant, effective monitoring of hypertension has become an indispensable practice conditioning patients' quality of life [1, 11].

Impedance cardiography (IC) is a method which allows for a precise determination of the initial cause of hypertension, and in consequence, for the selection of the most optimal scheme of treatment [12, 13].

Smith et al. [14] proved that hypertension treatment based on the hemodynamic parameters of impedance cardiography, such as: SVRI, TFC and CI, has a significant influence on the reduction of blood pressure. Similar results were obtained in this study. It was indicated that, similarly to Smith et al. [14], the values of hypertension significantly decreased, below 140/90: 66.8 *vs.* 55.1%, and below 130/80: 23.5 *vs.* 18.9% in the patients whose treatment was based on IC hemodynamic parameters in comparison with the patients treated on the basis of EBM. Moreover, similarly to Smith et al. [14], a statistically significant decrease of SBP and DBP was found in the final stage in the patients treated on the basis of IC parameters. However, Krzesiński et. al [15] found a reduction of blood pressure below 130/80: 36.6% *vs.* 23.5% in the group of patients treated on the basis of IC parameters in comparison with the patients treated on the basis of EBM. However, in the group of patients treated on the basis of EBM the blood pressure was found to drop below 140/90: 52.9% *vs.* 51.2% in comparison with the patients treated on the basis of IC parameters. Krzesiński et al. [15] showed that these differences also concerned the lower values of SBP and DBP. A statistically significant decrease in these parameters was observed during the two stages of the study. However, no decrease of SBP and DBP was found at the final stage of the study. The above discrepancies may result from the obtained values of the SVRI parameter. Abdelhammeda et. al [16] observed that SVRI is higher in patients with hypertension in comparison with healthy subjects. Also, they indicated that the higher the value of hypertension, the higher the values of SVRI. Therefore, SVRI significantly affects the values of blood pressure. Both Smith et al. [14] as well as the authors of this paper obtained a significant decrease of SVRI at the final stage of the study. However, Krzesiński et. al [15] did not obtain a statistically significant decrease of SVRI at any stage of the study.

The above results indicate that the method of impedance cardiography aids the treatment and monitoring of hypertension [17]. This method allows for the individualized treatment of each patient on the basis of hemodynamic parameters, facilitating the choice of the optimal treatment regimen or its modification by effective changes of doses and drug combinations. Owing to this method, the values of blood pressure may be significantly decreased, which in turn may lead to lower risk of cardiovascular complications and related deaths [14, 18–20].

Conclusions

Impedance cardiography allows for the non-invasive, repeatable and precise monitoring of hypertension treatment. Moreover, therapeutic treatment based on this method guarantees a significant reduction of blood pressure and the choice of the most effective treatment strategy.

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