

Electrophotonic Imaging Technology in the Diagnosis of Autonomic Nervous System in Patients with Arterial Hypertension

Abstract

Objective: To study the difference between patients with arterial hypertension and healthy people on the activity of brain functions and autonomic nervous system.

Materials and Methods: 138 patients (32 healthy and 106 patients with arterial hypertension) aged 20 to 70 years were examined using the methods of Electrophotonic imaging (EPI or gas discharge visualization GDV) and heart rate variability (HRV).

Results: The analysis of the data revealed statistically significantly different EPI/GDV parameters in patients with arterial hypertension and healthy subjects. The values of the medians of parameters indicated the activity of the right hemisphere of the brain in patients with hypertension, most pronounced in individuals with the II degree of the disease. The comparison also revealed statistically significant difference in the index of stress of regulatory systems, while in patients with arterial hypertension it was much higher than normal.

Conclusion: The possibility of identifying patients with high functional activity of the right hemisphere of the brain using the method of EPI/GDV can serve as one of prognostic factors of the arterial hypertension. Such diagnostic capability of the method can be particularly useful, for example, in case of timely detection of latent forms of hypertension.

Keywords: Electrophotonic imaging; Gas discharge visualization; Arterial hypertension; Right hemisphere

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Abbreviations: HRV: Heart Rate Variability; GDV: Gas Discharge Visualization; EPI: Electrophotonic Imaging; ANS: Autonomic Nervous System; AH: Arterial Hypertension

Introduction

A significant prevalence of arterial hypertension (AH), its role in the early decline of health, disability and mortality determined the relevance of this study. Despite the fact that the history of the study of AH has more than 130 years, if counting from the appearance of the first devices for measuring blood pressure, there are still many unclear and controversial issues in the pathogenesis of this disease and in the development of the most effective methods, tools and schemes for its treatment [1]. However, there is no doubt that the effectiveness of AH treatment is determined by the knowledge of the pathogenic mechanisms of its development and stabilization.

The complexity of the study of hypertension is due to the multifactorial nature of its etiology, the variety of manifestations and the involvement of almost all systems of the body in its development. Furthermore, it is known that the pathogenesis of this disease has gender differences [2]. Studies of hypertension indicate the cerebral hemispheres dysfunction in patients with this disease. While more and more scientists are inclined to believe

that a significant role in the formation of the AH should belong to the right hemisphere of the brain. This is also confirmed by the relationship between the functioning of the right hemisphere and blood pressure [3,4].

Modern methods of AH diagnostics open up prospects for new approaches to the study of the unsolved problems in the formation of AH, and hence to the search for more effective treatments for this disease. In our work an attempt was made to use for assessment of the functional state of the right hemisphere of the brain one of these new methods of bioelectrography Electrophotonic imaging (EPI/GDV). This method has found applications in the study of the functional activity of the organism in a wide range of diseases [5-8].

Materials and Methods

EPI/GDV method is based on mathematical analysis of the parameters of the glow of the skin stimulated by the pulses of electric field [5]. This is one of the few diagnostic methods to assess the state of the organism as a whole as well as of individual organs or systems. It is also possible to examine the functioning of the hemispheres of the brain.

In addition to the EPI/GDV, the method of heart rate variability (HRV) was used in the study. This is a method of registration of

the heart sinus rhythm with subsequent mathematical analysis. 138 people of both genders (65 men and 73 women) aged 20 to 70 years served as subjects in the study. Of these, 32 healthy volunteers formed the control group and 106 the group of patients with hypertension. The hypertension group consisted of 39 people with AH of I degree, 54 with AH of II degree and 13 with AH of III degree. 95% of subjects according to their subjective opinion were right-handed. Almost all the hypertension patients were constantly taking drugs to reduce blood pressure. Before the study medications were canceled. Examination of patients was carried out consistently in the first half of the day (from 8 to 12 hours), before meals.

The analyzed subjects have been selected on the basis of data of the patients of the Hospital №85 of FMBA of Russia, Moscow and submitted to the Department of functional diagnostics by various indications. The diagnosis of hypertension was staged in accordance with the recommendations of the Russian scientific society of cardiology [9]. Among patients with arterial hypertension 14.4% were diagnosed for the first time, the rest 85.6% had this disease from 3 to 15 years. The age range was 20 - 70 years.

Exclusion criteria

Patients with disturbance of the rhythm or conduction of the heart (frequent extrasystoles, atrial fibrillation, sinoatrial and atrioventricular block), as well as patients with implanted pacemaker. Women in menstrual period.

In accordance with international standards of interpretation of the results of the heart rate variability proposed in 1996 by the European society of cardiology and North American society of synthesis methods [10], patients with arterial hypertension were divided into two groups according to the value vago-sympathetic index ($LF/HF \leq 2$ and $LF/HF > 2$) and two groups according to the value of the index of tension of regulatory systems ($SI \leq 150$ and $SI > 150$).

For the HRV analysis, the device "Polispekt" ("Neurosoft," Russia www.neurosoft.ru/eng/) was used. The entry consisted of 5 minutes of ECG recording (no less than 300 cardio cycles) in the supine position. The study included only patients with sinusoidal rhythm without the presence of frequent extra systoles. For the GDV analysis, the devices "GDV Pro" and "Bio-Well" ("Bio-Well," USA, Estonia) were used.

Statistical processing

Character of distribution of investigated parameters was performed using Smirnov color criteria test; statistical differences was tested by Mann-White U-criterion, frequencies difference by Tony Fisher criterion. For building decision rules discrimination and logistic regression analysis were applied. Data processing was done using MS Office Excel, SPSS 17.0 and Statistica 7.0 programs.

Results

To identify differences between the control group (32 persons) and the group of patients with hypertension (106 people) 224 EPI/GDV indexes (112 right and left hands) and HRV index of tension of regulatory systems (SI) were selected. Statistically significant

differences ($p < 0.05$) were detected for 53 EPI parameters, 19 of them for the right hand and 34 for the left. Moreover, among the parameters of the right hand 7 related to the whole hand, while 12 to different sectors, reflecting the state of the nervous system, cerebral cortex, hypothalamus, hypophysis, epiphysis, adrenal glands, heart, vascular system, vessels, brain, kidneys. Among the indexes of the left hand 10 related to the whole hand, while 24 to the sectors of nervous system, cerebral cortex, hypothalamus, pituitary gland, pineal gland, adrenal glands, heart, vascular system, cerebral vessels, left and right parts of the heart, coronary vessels and kidneys.

Thus when comparing control group with a group of hypertension patients the asymmetry in the number of significantly different parameters with a predominance of EPI parameters of the left hand was revealed. It should be noted that such differences can be traced both in the parameters characterizing the luminescence of each finger as a whole, and sector parameters reflecting the condition of specific organs and organ systems.

Because the left hand carries information about the right half of the cerebral cortex [5], such laterality confirms the literature data indicating increased functional activity of the right hemisphere in individuals with hypertension [11].

The group of patients with hypertension was as well statistically significantly different from the control group ($p < 0.05$) on the HRV SI parameter. In the control group the SI median and the 25th and 75th percentiles (interquartile range) were respectively 82.46 (49.13; 129.21) and in the group of patients with hypertension 182.68 (109.97; 322.80). The SI norm is in the range from 80 to 150 [14], so its high value in the group of patients with hypertension indicated the high degree of centralization of heart rhythm control. The number of significantly different EPI parameters when compared the control group and the group of patients with hypertension of I, II, III degree is presented at Figure 1.

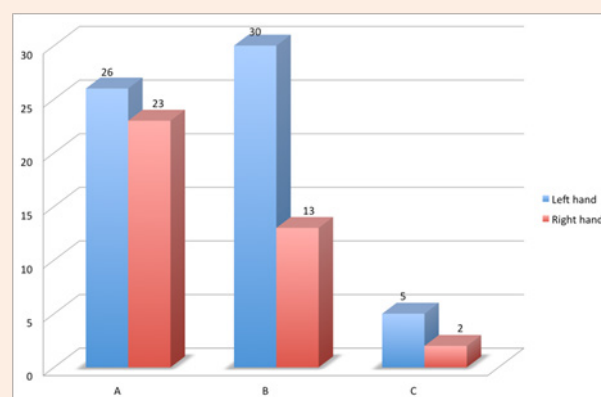


Figure 1: The number of significantly different EPI parameters when compared the control group and the group of patients with hypertension of I (A), II (B), and III (C) degree.

Thus, in each of the comparisons there is asymmetry in the amount of statistically significantly differing EPI parameters with a predominance of those on the left hand. It's expressed

most clearly in comparing the control group with a group of patients with AH of II degree (Table 1). We can assume that in patients with arterial hypertension of II degree, in comparison with patients with hypertension of I degree, the influence of the right hemisphere is most pronounced and stable, which generates stable arterial hypertension.

Table 1: Significantly differing organs and system based on Traditional Chinese Medicine sector analysis in comparing the control group and the group of patients with hypertension of I, II, III degree.

| Hand | Comparing the Control Group and Patients with Hypertension of I Degree | Comparing the Control Group and Patients with Hypertension of II Degree | Comparing the Control Group and Patients with Hypertension of III Degree |
|-------|--|---|--|
| Left | Nervous system | Nervous system | |
| | The cerebral cortex | The cerebral cortex | |
| | The hypothalamus | The hypothalamus | |
| | The pituitary gland | The pituitary gland | The pituitary gland |
| | Epiphysis | Epiphysis | Epiphysis |
| | Adrenals | Adrenals | |
| | Vascular system | Vascular system | |
| | Heart | Heart | |
| | The brain vessels | The brain vessels | |
| | The right chambers of the heart | The right chambers of the heart | The right chambers of the heart |
| | Coronary vessels | Coronary vessels | Coronary vessels |
| | | The left chambers of the heart | |
| | Kidneys | Kidneys | |
| Right | Nervous system | Nervous system | |
| | The cerebral cortex | | |
| | The hypothalamus | The hypothalamus | |
| | The pituitary gland | The pituitary gland | |
| | Epiphysis | Epiphysis | |
| | Adrenals | Adrenals | |
| | Vascular system | Vascular system | |
| | Heart | Heart | |
| | The brain vessels | The brain vessels | The brain vessels |
| | Coronary vessels | | |
| | Kidneys | | Kidneys |

Interesting observations may be done by comparing the medians of parameters which have statistically significant difference for the control group and groups of patients with different degrees of hypertension (Table 2). These ratios were observed both for the individual fingers as a whole and for sectors, corresponding to particular organs and systems. It is known that the pathogenesis of this disease has gender differences and high values of LF/HF in men, both healthy and patients with hypertension, compared to

women, are not due to the age difference [8,12,13]. At the same time In developed diagnostic rules in a complex of independent variables for classification groups of patients with LF/HF ≤ 2, and LF/HF > 2 parameter "Gender" was included, while for classification of patients into groups with SI ≤ 150 and SI > 150 parameter "Age" was included. Thus, the values of LF/HF are dependent on gender, and the values SI- from age. This conclusion was confirmed in later studies on the group of 157 patients.

Table 2: The results of the comparison of medians statistically significantly different EPI parameters of the control group and groups of patients with different degrees of hypertension.

| EPI parameters | Characteristic of Median of the EPI Parameters of Patients with Hypertension Compared with the Control Group |
|-----------------------|--|
| Image Area | Reduced |
| Image normalized area | Reduced |
| Specter width | Reduced |
| Image brightness | Reduced /Increased |
| Image density | Reduced |
| Image fractality | Increased |

Discussion

According to the obtained results we can conclude that patients with hypertension, regardless of the severity of the disease differ from healthy persons more on the parameters of the left hand than the right. For BA patients all parameters which characterize the amount and spectral characteristics of photons emitted by the skin (image area, brightness and density) are reduced, while fractality parameter, which characterizes the irregularity of the image, is increased. Such a feature in patients with arterial hypertension may be associated with the presence in them of a sympathetic-parasympathetic imbalance, which contributes to increased perspiration the skin and leads to the formation of pricorneva layer saturated with water molecules. From the physics of gas discharge it is known that the development of sliding discharge in the atmosphere of water vapors is suppressed and glow intensity is significantly decreased. This is because the dielectric constant of water is 80 times greater than the permeability of air, which influences ionization potential [5]. Figure 2 shows examples of EPI images of one of the fingers of the left hand of AH patient (left) and practically healthy person (right).

According to the literature, in healthy individuals in a state of relative calmness observed stable prevalence of electrodermal resistance level (EDR) of the left hand, which is a symptom of a relatively high alpha-activity of the right hemisphere of the brain, while a predominance of alpha depression in the left hemisphere responsible for a relatively low EDR level of the right hand. The inverse relationship between the EDR levels observed in patients in a state of emotional stress [15]. Given that patients with hypertension had low EDR of the left hand fingertips, which distinguished them from the healthy control group, we can assume that such patients had a high functional activity of the right hemisphere of the brain. It is also possible that they may

have the emotional stress caused by negative emotions, because the right hemisphere to a greater extent responsible for negative emotions, in particular, due to changes in alpha activity [16].

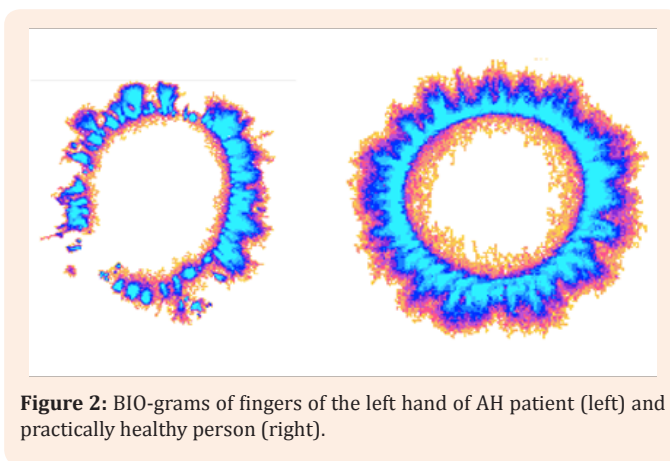


Figure 2: BIO-grams of fingers of the left hand of AH patient (left) and practically healthy person (right).

Besides we know that there is a functional dependence of the sympathetic division of the autonomic nervous system on the activity of the right hemisphere of the brain [2]. This suggests that activation of the right hemisphere of the brain, emotional stress and high activity of the sympathetic nervous system in patients with hypertension should be considered in a pathogenetic chain of this disease. In order to assess the degree of activity of the sympathetic nervous system or the degree of centralization in hypertensive patients depending on the severity of the disease, we compared the control group with the group of patients with hypertension of I, II, III degree on the HRV SI parameter. This study revealed statistically significant differences (Table 3).

Table 3: The index of tension of regulatory systems in the control group and in groups of patients with hypertension of I, II, III degree (median and interquartile range).

| | Norm | Control Group | AH I Group | AH II Group | AH III Group |
|----|--------|----------------------|-----------------------|------------------------|------------------------|
| SI | 80-150 | 82.46 (49.13;129.21) | 181.34 (87.68;355.25) | 171.33 (109.97;264.29) | 275.07 (183.70;298.31) |

Image Area

Amount of light quanta generated by the subject in computer units-pixels (the number of pixels in the image having brightness above the threshold).

Image normalized area

The ratio of BIO-gram area to the area of the inner oval. This parameter allows comparing BIO-grams of people having fingers of different sizes.

- a) Specter width-Evaluation of light specter
- b) Image brightness- Averaged spectrum brightness
- c) Image density- Amount of brightness levels
- d) Image fractality- Evaluation of contour fractality

As follows from these data, the degree of centralization of heart rhythm control in all patients with hypertension, regardless of the severity of the disease, went beyond the normal range, and were high in comparison with the control group. Since it is known that the stress index has a high sensitivity to increased tonus of the sympathetic nervous system [1], we can conclude that the excess of the normal values of this index in hypertensive patients indicates the predominance activity of the sympathetic nervous system for such patients. Thus, patients with hypertension have not only the tendency to activity of the right hemisphere, but also to increased sympathetic tone.

Violation of the neurogenic regulation of blood circulation over a long period of time is considered as the most important pathogenic link in the development of hypertension. Studies of arterial hypertension indicate a dysfunction in the cerebral hemispheres in patients with this disease. Switching of the functional activity of brain hemispheres in solving some tasks, when for some time the subdominant hemisphere becomes the leading one, was detected in healthy people, while for hypertensive patients this was not detected [17,18,]. Scientists are inclined to believe that the reason for this may be specific functioning of the right hemisphere of the brain, which, therefore, starts the process of formation of AH. This is confirmed by the established connection between the functioning of the brain right hemisphere and blood pressure [4], and the fact that the right hemisphere is dominant in processing of cardiovascular information.

It is known that hypothalamus and pituitary play the key role in stress, thus increasing the activity of diencephalic structures of the sympathetic nervous system [19] and enhancing right-brain functioning [20]. The maximum changes in stress reactions also localized in the right hemisphere [21]. This confirms the neurogenic theory of hypertension and the current understanding of hypertension as psychosomatic disease [22,23]. However, there is still no clear idea about the functioning of the right hemisphere in patients with arterial hypertension. Some authors suggest that the increased functional activity of the right hemisphere contributes to the development of hypertension [19,24-26], while others believe that the development of hypertension is associated with the reduced activity of the right hemisphere [27,28].

Study on the comparison of the velocity of the pulse wave propagation in healthy patients with elevated anxiety and patients with cardiovascular disease, which included patients with congestive heart failure, hypertension and coronary heart disease showed statistically significant differences in these groups on several indexes [29]. The highest values of indexes compared to the healthy group were observed in anxious patients, patients with congestive heart failure, patients with hypertension and patients with ischemic heart disease. This was attributed to the weakening of vagal activity on the left side of the body, which is activated by the right hemisphere. It has been shown that among patients

with borderline hypertension the percentage of individuals with the right type of inter-hemispheric asymmetry was significantly higher than among healthy population (respectively and 35.3% and 27.3%) [25].

Thus, the literature on the value of the activities of the cerebral hemispheres in a complex chain of formation AG, indicate a pronounced connection between the functioning of the right hemisphere and the development of hypertension. However, the ambiguity of the results obtained in defining the very nature of the functioning of the right hemisphere at a given nosological form leaves the question open.

Conclusion

The results of our work confirm the special importance of the central nervous system in arterial hypertension, in particular the right hemisphere of the brain. The above may serve as a confirmation in favor of the concept of high functional activity of the right hemisphere in this disease, which may manifest in these patients in the form of strengthening the degree of centralization of heart rhythm control. Moreover, in patients with hypertension of II degree the activity of the right hemisphere is more pronounced and stable than that of patients with hypertension of I degree.

The analysis of the data revealed statistically significantly different EPI/GDV parameters in patients with arterial hypertension and healthy subjects. The values of the medians of parameters indicated the activity of the right hemisphere of the brain in patients with hypertension, most pronounced in individuals with the II degree of the disease. The comparison also revealed statistically significant difference in the index of stress of regulatory systems, while in patients with arterial hypertension it was much higher than normal.

The possibility of identifying patients with high functional activity of the right hemisphere of the brain using the method of EPI/GDV can serve as one of prognostic factors of the arterial hypertension. Such diagnostic capability of the method can be particularly useful, for example, in case of timely detection of latent forms of hypertension.

Conflict of Interest

Authors have no conflict of interest.

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