Chronobiological and morphofunctional aspects of arterial hypertension under circumpolar conditions

Polyakov VYa.

Scientific Centre of Clinical and Experimental Medicine SB RAMS

ABSTRACT

Introduction. Nowadays the problem of population health in the northern areas is of great importance. While evaluating human adaptation to the extreme geoeccological northern conditions the state of the cardiovascular system can be used as an index of effective compensatory adaptation. Study design. The data on 24-hour BP monitoring, data of echocardiography and heliogeophysical factors in different periods of ontogenesis in 317 patients, living in the north of the Tyumen region, were analysed to estimate the morphofunctional and chronobiological peculiarities of arterial hypertension. Results. Considerable disorders of haemodynamic circadian rhythms, manifesting either insufficient decrease of BP at night are revealed in the examined subjects. Above 42.2% of such patients have myocardial hypertrophy. Insufficient night decrease of BP is typical for the examined patients, with coupling of the indices of haemodynamic and current geomagnetic activity. The peculiarities of heliogeophysical factors at early ontogenesis of the examined subjects with an increased variability and decreased circadian index of BP are defined using multivariate analysis. Conclusion. Thus, a combination of disorders of temporary haemodynamic organisation with the morphological changes of myocardium and peculiarities of biogeophysical coupling of the examined is shown. This anthropoecological approach can be used for the diagnostics and treatment of arterial hypertension under conditions of the northern ecosystem.

Keywords: arterial hypertension, 24-hour BP monitoring, chronobiological.

INTRODUCTION

The development of northern territories of the planet is a great achievement for mankind. For thousands of years, native peoples of the North have been adapting to the natural and climatic conditions of this severe but wonderful region. However, the present dynamic social-economic development poses the challenge of quick adaptation to the ecology of the North for people and populations.

We know that the respiratory and, of course, cardiovascular systems play the main role in the physiological processes of compensation and adaptation of the human organism to the northern nature (1,2). Unfortunately, ineffective or poor adaptation leads to the development of the hypertension syndrome. The prevalence and severity of the clinical course of this syndrome is increasing in the immigrant population of the North. Most researchers consider arterial hypertension to be a poly-cause and multi-factor pathology, in the manifestations of which complex internal and external causes play a significant role (3). Unfortunately, the role of a geoeccological factor such as the heliogeophysical medium has been poorly investigated in predicting the risk of occurrence and acute condition of the disease (4).

At present time new diagnostic and treatment methods provide an effective help in the efforts to improve the health and life of arterial hyperten-
sion sufferers. Such methods include ultrasonic investigation of the heart and lung (for 24 hours or more), monitoring of the blood pressure and cardiac rate.

The circadian blood pressure profile is considered to be an integral functional characteristic of the cardiovascular system, reflecting the severity and pathogenetic characteristics of the disease. It is associated with the neuroendocrinological and metabolic status of the patients and the morphofunctional characteristics of the cardiovascular system (5). Arterial hypertension patients with an insufficient nocturnal blood pressure decline (less than 10%) have vegetative imbalance with an increased peripheral and central sympathicotonia at night (6,7). Such patients are natrium-sensitive and natrium-dependent (8). Also, they have a changed glycaemic profile at glucose stress and increased cardiovascular risk at a young age. Besides, diastolic dysfunctions of the left ventricle appear at early stages of the disease. Some of the patients have more pronounced myocardium hypertrophy of the left ventricle (9).

At the same time, blood pressure dynamics also depend on the state of external factors, in particular the heliogeophysical medium, which plays an important role in the formation of ecology of the North (4). Extreme conditions of the heliogeophysical medium can cause a deterioration of the state of the cardiovascular system. According to investigation data, the period of minimal geomagnetic activity is associated with the bioelectric instability of the myocardium. In the period of an unstable geomagnetic field, the state of microcirculation deteriorates, capillary blood flow decreases, platelet aggregation enhances, and the formation of blood clots accelerates.

However, the sensitivity of patients to changes in the heliogeophysical medium is not uniform. Patients with higher vegetative lability and magnetosensitive patients are more sensitive. Solar activity and the state of the Earth’s magnetic field in the period of early ontogenesis can have a significant effect on the peculiarities of reaction of the cardiovascular system to changes in the heliogeophysical medium (4).

In the light of the above data, it is clear that it is important to study in connection with arterial hypertension the possibility of a dynamic correlation between blood pressure and cardiac rate and the geomagnetic activity, and the formation of peculiarities of circadian haemodynamic rhythms in such patients.

The purpose of the investigation carried out was to estimate aspects of the correlation between the morphofunctional characteristics of the cardiovascular system, in particular, the circadian blood pressure dynamics, and the heliogeophysical factors of the medium in arterial hypertensives in the conditions of the North.

MATERIAL AND METHODS

The group of patients under investigation included 317 arterial hypertension patients living in the north of the Tyumen region (Western Siberia). The age of the patients ranged from 18 to 65.

The following methods were used in the investigation.

1. Twenty-four-hour blood pressure monitoring and echocardiography.
2. A computer program called "Gelios – Mlechnyi Put" (certificate № 20011611270, 24.09.2001). This program uses a database about the cosmophysical situation in the period from 1900 to 2000. With the help of this computer program, information can be obtained about the dynamics of cosmophysical factors at any time of human life.
3. Monitoring of the heliogeophysical medium (on the basis of the data from orbiting space and ground stations of astronomic and magnetic-ionospheric observation).

Statistical treatment of the data was carried out with the help of standard computer software packages called Statistica and SPSS 10.0. Also, multi-factor analysis was performed using the "solution tree" algorithm in the "LASTAN"
RESULTS
In the group of arterial hypertensives (a total of 317 people) 171 (53.9%) patients had nocturnal hypertension and insufficient nocturnal decline in systolic blood pressure (SBP), 137 (43.2%) of them had physiological nocturnal decline, and 9 (2.9%) had an excessive nocturnal decline. As for the level of diastolic blood pressure (DBP), nocturnal hypertension and insufficient nocturnal blood pressure decline was observed in 168 (53.0%) patients, physiological nocturnal decline in 127 (40.1%) and excessive nocturnal decline in 22 (6.9%) of those investigated. 139 (43.2%) people had simultaneous insufficient nocturnal decline of systolic and diastolic blood pressure (Table I). These figures show that the number of failures in the circadian blood pressure dynamics increases (and insufficient nocturnal blood pressure decline prevails) in the examined group in comparison to the occurrence of such blood pressure profile in hypertensive patients on the whole. In the literature, this figure constitutes up to 26 per cent.

The group of patients with an insufficient nocturnal blood pressure decline had myocardial hypertrophy of the left ventricle much more often - 42% - than those with a normal circadian blood pressure profile, 22% (table II).

**Table I.** Circadian BP profile of hypertensives living in the north of Western Siberia (n=317).

| Circadian blood pressure profile | SBP   | DBP   | SBP and DBP |
|----------------------------------|-------|-------|-------------|
| Nightpeaker and non-dipper       | 171   | 168   | 139 (43.9%) |
| Dipper                           | 137   | 127   | 127 (40.1%) |
| Over-dipper                      | 9     | 22    | 22 (6.9%)   |

**Table II.** Patients with myocardial hypertrophy in hypertensives with different circadian BP profile (n=216).

| Circadian blood pressure profile | All patients | Myocardial hypertrophy |
|----------------------------------|--------------|------------------------|
| Nightpeaker, non-dipper          | 116          | 49 (42.2%)             |
| Dipper                           | 95           | 21 (22.1%)             |
| Over-dipper                      | 5            | 1 (20.0%)              |

Estimation of the correlation between haemodynamic values and geomagnetic activity was made in a group of 119 patients. A three-hour ak-index was used as a characteristic of geomagnetic activity. The correlation was estimated by the systolic, average dynamic, diastolic blood pressure and the heart rate. Correlation analysis was used. Fifty-eight of those investigated had a correlation between one of the haemodynamic indices and the current geomagnetic activity. Moreover, in this group the nocturnal blood pressure decline was 4.9%, whereas in the group without the “biogeophysical correlation” it was 12.3%, i.e. within normal range (Figure 1).

Multi-factor analysis by using the "solution tree" algorithm of
the "LASTAN" computer program was used to detect regular dependences in the following groups of parameters, including the characteristics of the cardiovascular system and heliogeophysical system in the early ontogenesis of patients:

- higher solar activity was observed in the early ontogenesis (in the first month after birth) of patients with higher systolic blood pressure in the daytime;
- higher geomagnetic activity was observed in the early ontogenesis (in the first month after birth) of patients with higher systolic blood pressure in the nighttime;
- a higher level of geomagnetic activity was observed during the first month before the calculated conception date of patients with less pronounced nocturnal blood pressure decline;
- the patients with high blood pressure variability in the daytime (in accordance with the data of 24-hour monitoring) had high solar activity in combination with low geomagnetic activity during the month before the calculated conception date in the early period of individual development.

**DISCUSSION**

Thus, circadian rhythms of haemodynamics are formed, on the one hand, under the influence of correlation between metabolic and functional systems of a human organism. On the other hand, they are synchronised with the external conditions of the medium, which are varying both periodically and aperiodically. Heliogeophysical factors are universal timers. Therefore, their chronobiological role for humans and, in particular, for their cardiovascular system is essential and very important. It is assumed that the modulating influence of a geophysical characteristic of the medium, such as the geomagnetic field, on a human organism is partly mediated by the correlation between regulatory processes in the nervous and endocrine systems, as well as by the correlation between reductive-oxidative processes in cell membranes. Circadian blood pressure variation in subjects with arterial hypertension in the North can be considered to be a feature of external and internal desynchronism, which develops at the adaptation to new conditions. These phenomena are described in the literature, and have corresponding endocrine, metabolic and functional manifestations (2).

Taking into account the fact that in modern biology and, in particular, in biophysics, the optimisation of correlation between metabolic processes inside biosystems plays a special evolutionary role, one can speak about the evolutionary role in the formation of optimal circadian haemodynamic rhythms in humans that live in northern conditions.

There is one more aspect of the issue under consideration. In the biological respect, the human organism is an open system. The interrelations formed in these conditions between the biochemical components of the system and its spatial-structural formations, including the cardiovascular system, can be considered a coherent behaviour. Within the framework of this behaviour, there can be consistency between periodic and aperiodic changes inside the system. In accordance with this concept, the sensitivity of highly non-equilibrium states to external oscillations can increase abruptly, and the system response is mostly determined by its state. In this case, one more peculiarity is the enhancement of long-range correlations (10). This can partly explain the relation between the haemodynamic parameters and the heliogeophysical factors of the medium in early ontogenesis.

**CONCLUSIONS**

1. The clinical-diagnostic data of twenty-four-hour blood pressure monitoring analysed jointly with the data of heliogeophysical monitoring make it possible to estimate the functional sensitivity of the human cardiovascular system to geoeological factors of the medium.

2. In the conditions of the North, the circadian blood pressure profile at arterial hypertension is characterised by a decline of the circadian index of BP, accompanied by a more pronounced myocardium hypertrophy of the left ventricle.
and specific haemodynamic sensitivity to geomagnetic activity formed in ontogenesis.

3. Multi-factor analysis makes it possible to reveal nonlinear dependencies between haemodynamic indices and the state of the heliogeophysical medium during the early period of human ontogenesis.

Thus, a combination is shown of disorders of temporary haemodynamic organisation with the morphological changes of myocardium and peculiarities of biogeophysical coupling in different periods of ontogenesis of the examined patients. Within the framework of a new anthropoecological approach this allows us to conduct diagnosis and correction of arterial hypertension under conditions of the northern ecosystem.

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Polyakov VYa.
Laboratory of helioclimatopathology
Scientific Center of Clinical and
Experimental Medicine SB RAMS
Academician Timakov’s st., 2
Novosibirsk
630117
Russia

Email: isrica2@rumbler.ru