

Hypertensive Crisis and Space Weather at High Latitudes (on the Example of Yakutsk)

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ABSTRACT

A comparison of electronic database of patients' visits complaints to ambulance (ECM) in Yakutsk was made to assess the impact of space weather on the well-being and condition of people with cardiovascular pathology. It has been shown that during the years of high solar activity there are significant coincidences between changing geomagnetic perturbation (Kp-index) and the number of patients' visits to polyclinics with high BP. The number of calls for emergency medical care due to high blood pressure was observed in 57 % of cases, in people with primary essential arterial hypertension (AH), 7% of them had a hypertensive crisis (HC) with systolic blood pressure 180 mmHg, diastolic blood pressure 120 mmHg. In connection with the significant coincidence of medical data and Kp-index, a conclusion was made about the possible influence of heliogeophysical perturbation on the cardiovascular system of a person living at high latitudes.

Keywords: *hypertensive crisis, space weather, cardiovascular pathology, solar activity, geomagnetic perturbation, Yakutsk*

1. INTRODUCTION

The influence of environmental parameters on human health, the determination of their contribution to the development of pathology is a relevant topic nowadays. In addition to clearly influencing environmental factors, such as meteorological parameters, as well as social factors, it was found out that electric and magnetic fields, corpuscular and electromagnetic particles and radiation not recorded by human senses can have an impact on his state of health.

At the end of the last century after the first flight of a spacecraft measuring the parameters of particle flows, after the electromagnetic fields and radiation, there appeared an understanding of the interplanetary environment, and how the fields, particles and radiation can reach a particular area of the interplanetary environment and have an effect on the Earth's life. And at the beginning of our century the term "space weather" appeared. It characterizes the interplanetary environmental conditions. The Sun has the main

influence on the state of near-Earth outer space. The identification of mechanisms of communication between the activity of the Sun and the functioning of various objects of the biosphere, including humans, is one of the fundamental problems of modern science [1].

Many researches have been published on the space weather effect on human health, for example: Baevsky et al., 1994 [2]; Cornelissen et al., 1994, 1996 [3, 4]; Watanabe et al., 1994 [5]; Otsuka et al., 1996, 1997, 2000 [6–8]; Halberg et.al., 1994 [9]; Breus et.al., 1995, 2012 [10, 11]; Chibisov et al., 1995, [12]; Lednev et al., 1996 [13]; Gurfinkel et al., 1995, 2018 [14, 15] etc. But there are still many unclear questions about the specific parameters of space weather affecting humans and the mechanisms of such an influence on various systems of the body.

The circulatory system is a regulated convective transport system necessary to maintain all vital functions of the body. It has a fairly thin, fast and at the same time complex nervous and humoral regulation. It

is one of the first that involves adaptation mechanisms when exposed to various factors on the human body and one of the first that undergoes pathological changes, often manifested by the development of arterial hypertension.

Currently, the problem of the pathogenesis of arterial hypertension is being actively studied by leading world institutions [1]. J.I. Gurfinkel et al. (2018) investigated the vascular tone characteristics of healthy individuals and showed that arterial stiffness and endothelial function, as well as blood pressure and heart rate, depend on geomagnetic and, in most cases, weather conditions. The most sensitive to the effects of space weather was the rate of pulse wave propagation, characterizing the stiffness of the arteries. Endothelial dysfunctions and response of pulse frequency to variations of geomagnetic activity indicate possible involvement of nitrogen monoxide in the process of body "adjustment" to variations of geomagnetic field [15].

The territory of Yakutia, located in the region of high latitudes and, due to geophysical and atmospheric features, is situated in the zone of the most influenced geophysical factors of space weather. The pathogenetic features of arterial hypertension development in the northern regions may be related to the fact that blood pressure increase can be considered as a perverse adaptive reaction of the body to the effects of extreme climatic and geophysical factors. Such adaptive hypertension can be considered as a consequence of hemodynamic compensation by the body of impaired metabolism. In the works of V.I. Hasnulin and others, it is indicated that the cause of the crisis course of arterial hypertension (AH) in the North is northern environmentally conditioned stress, called "polar stress syndrome." The main components of this syndrome are: oxidative stress, insufficiency of detoxification processes and barrier structures, metabolic disorders, tissue hypoxia, regenerative-plastic insufficiency, disorders of electromagnetic homeostasis, desynchronization, psychoemotional stress, meteoropathy [16]. These changes contribute to damage to target organs and faster progression of the disease with the development of acute cardiovascular disasters (heart attacks, strokes).

As part of this work, we planned to determine the connection between episodes of increased blood pressure in patients with hypertension during geophysical disturbances.

2. MATERIALS AND METHODS

To study the dynamics of health deterioration of people suffering from cardiovascular diseases living in high latitudes, statistical processing and analysis of the

electronic database of ambulance calls to Yakutsk of the Republic of Sakha (Yakutia) for 2014 was carried out.

A comparison was made of the number of cases of people's visits due to BP (SBP 140 mmHg; DBP 90 mmHg) and increase of BP level to critical values (SBP 180 mmHg; DBP 120 mmHg) with a Kp index characterizing the global level of heliogeophysical activity. Kp-index – characterizes the average deviation of the magnetic field of the entire planet from the norm. Measured in conditional units from 1 to 9. Calm state, respectively – 1. As the intensity grows, the value of the index grows.

For statistical data processing, the computer programs "Microsoft Office," "Origin," used for plotting and conducting statistical calculations, were used.

3. RESULTS AND DISCUSSION

To assess the impact of heliogeophysical perturbation on the health of people living in Yakutsk, emergency medical care data (ECM) were selected. For the analysis, cases of deterioration of people's well-being due to blood pressure increase and their comparison with the Kp-index (planetary geomagnetic perturbation index) for 2014 were selected. According to geophysical studies, 2014 falls on the maximum of the 24th 11-year cycle of solar activity, manifested by a general increase in geomagnetic perturbation (Fig. 1). Figure 1 is a graph showing the number of spots on the Sun (Wolf numbers) characterizing the corpuscular and electromagnetic activity of the Sun.

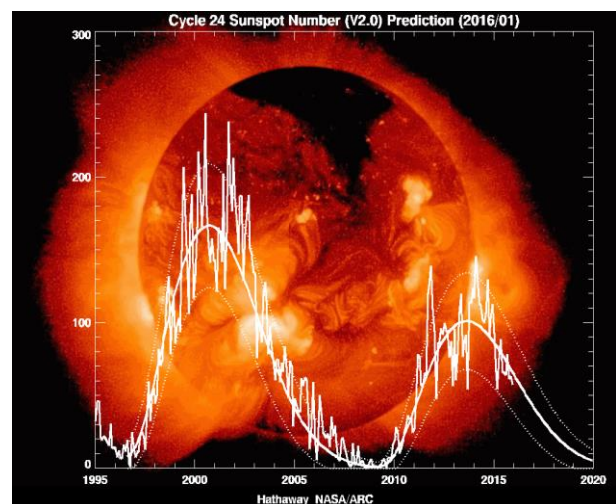


Figure 1. Wolf numbers for the 23rd and 24th 11-year cycle of solar activity

This graph clearly shows that there was a maximum number of Wolf spots = 120 in 2014. When compared with other years, 2009 and 2020, the minimum solar activity shows a decrease in the curve to 0 (zero) spots.

Analysis of case data regarding the increase in blood pressure (BP) and comparison with the Kp-index showed the following. In 2014, there were coincidences of the main changes in the Kp-index and the number of referrals of patients diagnosed with arterial hypertension (Fig. 2).

Figure 2 shows the total annual dynamics of the geomagnetic perturbation index and the number of patient calls of increased BP by day in 2014. This graph shows almost all peak matches of the two parameters under study, which may indicate the connection between these parameters.

A detailed analysis of case data due to increased blood pressure (BP) showed the following. In 2014, a total of 2,807 emergency calls for higher blood pressure (BP) were registered, 54 % of which were women (1,516), 46 % were men (1,291). Of the total number of calls for higher BP, people with primary (essential) arterial hypertension accounted for 57 % (1598).

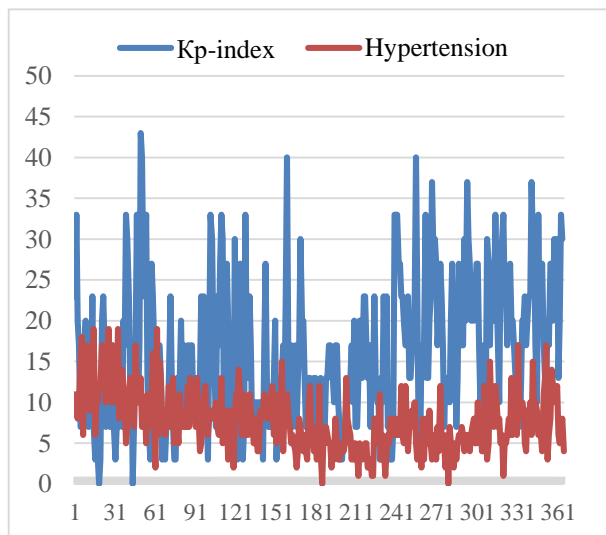


Figure 2. Change in the Kp-index of geomagnetic perturbation and the number of calls for arterial hypertension in days 2014

In most cases, arterial hypertension (59 %) was observed in older people aged 60 and over, which is a fairly standard indicator of the corresponding world statistics. Pathogenetic factors contributing to the development of arterial hypertension in the elderly are the high content of circulating angiotensin II in the blood, damage to the vascular endothelium and a decrease in the release of vasodilating substances [1].

59 % of all requests for emergency medical care are elderly and senile people, that is, people whose cardiovascular system reacts more strongly to more weak compared other factor – effect of geophysical activity. In many works, it has been shown that the effect of space weather factors causes an increase in hemostasis processes, lipid peroxidation, the reduction

of nitrogen oxide producing, the level of immune protection, carbohydrate and lipid metabolism, circadian rhythm melatonin expulsion, which is followed by an increase of a blood pressure, thrombosis enhancement, an increase of an insulin release and of HOMA-IR [17–20]. Middle-aged patients (less than 60 years) amounted to 1,151 people (41 %).

Hypertensive crisis was observed in 7 % of people (112) with primary (essential) arterial hypertension. Hypertensive crises are frequent complications of chronic arterial hypertension and are described in all its symptomatic and primary forms [21].

Hypertensive crisis refers to a condition characterized by a sudden critical increase in BP, accompanied by clinical symptoms requiring an immediate decrease in BP. On the background of a sharp BP increase, neurovegetative disorders, cerebral hemodynamics disorders, and the development of acute heart failure are possible. At the same time, BP increase to individually high digits is observed within minutes, a maximum of several hours.

The mechanisms for the development of hypertensive crises in various pathological conditions are different. Hypertensive crisis in essential arterial hypertension is based on impaired neurohumoral control of changes in vascular tone and activation of sympathetic influence on the circulatory system. A sharp increase in the tone of arterioles contributes to the pathological BP increase, which creates an additional load on the mechanisms of regulation of peripheral blood flow.

In addition to the age-related criteria in the development of arterial hypertension and other cardiovascular complications, the sex of patients is an important determining factor too. According to our data, out of 2807 ambulance calls for arterial hypertension women make up 54 % (1516) in 2014. It should be noted that men predominate among young patients 67 % (771). For women, this indicator is also stable and amounts to 380 out of 1151 or 33 %. The frequency of hypertensive crisis for women aged 50 years and older, on the contrary, is several times higher than for men: 75 against 37 (2 times). This fact can be explained by a decrease in adaptive mechanisms in women during menopause, which is accompanied by a deficiency of estrogens due to natural extinction of ovarian function and, apparently, increases their sensitivity to geophysical factors [22].

When analyzing the medical data of patients with hypertensive crisis, it was determined that 98 people (87.5 %) showed a simultaneous increase in both SBP and DBP, which corresponds to the eukinetic type of hemodynamics (according to A.P. Golikov), characterized by maintaining a normal cardiac output value and increasing total peripheral vascular resistance

(TPVR). This type of hemodynamics in arterial hypertension is relatively "benign" and is manifested by an increase in clinical symptoms, without severe disorders of target organs.

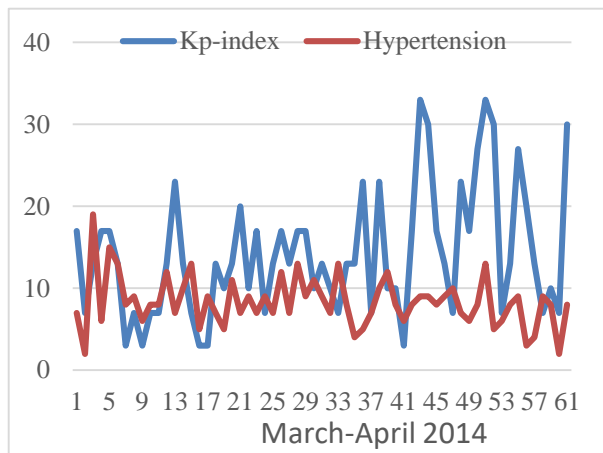


Figure 3. Kp-index change of geomagnetic perturbation and the number of calls for arterial hypertension in March and April 2014

The daily data for March and April 2014 are presented in more detail in Figure 3. The graph shows the coincidence of the dynamics of medical data and geomagnetic perturbation data for two months. Figure 3 shows that almost every change in geomagnetic perturbation makes people react with BP increase. In these months of the year, a larger number of complaints were observed than in other months of 2014. In 14 patients (12.5 %), a preferential increase in SBP with pronounced tachycardia was observed, which corresponds to the hyperkinetic type of hemodynamics with increased cardiac output in normal TPVR. According to the classification, this type of hemodynamics in its clinical picture corresponds to the first (I) type by N.A. Ratner and is associated with the activation of the sympathoadrenal system. It develops on the background of satisfactory well-being and without any precursors.

The coincidence of the dynamics of medical data and changes in geophysical parameters can indicate the effect of geomagnetic perturbation on the human circulatory system, thereby increasing the number of calls by people to the emergency centres.

4. CONCLUSIONS

The analysis of the data presented in the study shows the presence of a complicated, ambiguous connection of the number of requests for medical care for hypertensive crisis (HC) with geomagnetic activity. Nevertheless, the data studied agree with the previous results [1, 22] and allow us to state that such a relationship exists.

1. The coincidence of the maxima of the temporary change in geomagnetic perturbation (Kp-index) and the number of calls of patients to medical establishments due to AH in 2014 was determined. On this basis, a conclusion was made about the possible influence of geomagnetic perturbation on the state of the circulatory system of a person living at high latitudes.

2. In most cases, AH (59 %) was observed in adults older 60 and over. The number of calls for emergency medical care due to blood pressure increase is observed in 57 % of cases in people with primary essential arterial hypertension (AH), 7 % of them had a hypertensive crisis (HC) with SBP 180 mmHg and DBP 120 mmHg.

3. The increase in calls for medical care for AH in various periods of the year correlates with the increase in the intensity of the Kp-index of geomagnetic activity, the greatest manifestation of which was observed in the spring period of 2014.

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REFERENCES

- [1] A. Strekalovskaya, P. Petrova et al., *IJBM* 8(1) (2018) 56–59. Retrieved from: [http://dx.doi.org/10.21103/Article8\(1\)_OA9](http://dx.doi.org/10.21103/Article8(1)_OA9)
- [2] R. Baevsky, V. Petrov, G. Cornelissen et al., *Scripta med.* 70 (1997).
- [3] G. Cornelissen, H. Wendt, F. Guillaume et al., *Chronobiol.* 21 (1994).
- [4] G. Cornelissen, F. Halberg, H. Wendt et al., *Biol.* 51 (1996).
- [5] Y. Watanabe, D. Hillman, K. Otsuka et al., *Chronobiol.* 21 (1994).
- [6] K. Otsuka, G. Cornelissen, F. Halberg, *Clin. Drug Invest.* 11 (1996).
- [7] K. Otsuka, G. Cornelissen, F. Halberg, G. Oehlert, *Med. Engin. & Technol.* 21 (1997).
- [8] K. Otsuka, T. Yamanaka, G. Cornelissen, T. Breus et al., *Scripta med.* 73 (2000).
- [9] F. Halberg, G. Cornelissen, Y. Kumagai et al., *Chronobiol.* 21 (1994).
- [10] T. Breus, G. Cornelissen, F. Halberg, A. Levitin, *Ann. Geophys.* 13 (1995).

- [11] T.K. Breus, R.M. Baevskii, A.G. Chernikova, J. Biomed. Sci. 5(6) (2012).
- [12] S.M. Chibisov, T.K. Breus, A.E. Levitin, G.M. Drogova, Biophys. 40(5) (1995).
- [13] V.V. Lednev, L. Srebnitskaya et al., Biophys. 41 (1996).
- [14] Yu.I. Gurfinkel, V.V. Lubimov, V.N. Oraevski et al., Biophys. 40(4) (1995).
- [15] Yu.I. Gurfinkel, V.A. Ozheredova, T.K. Breus et al., Biophys. 63(2) (2018).
- [16] V.I. Khasnulin, Alaska Med. J. 49 (2007).
- [17] S.S. Parshina, S.N. Samsonov, V.P. Reutov et al., New inform. Technol. in med., boil., pharmacol. and ecol. 5 (2017).
- [18] S.M. Chibisov, Bull. of the Peoples' Friend. Univ. of Rus. 3 (2006).
- [19] V.I. Konenkov, V.V. Klimontov, S.V. Michurin et al., Diab. mellit. 2 (2013).
- [20] E. Schulz, Hypertens. Res. 34(6) (2011).
- [21] V.A. Lyusov, E.M. Evsikov et al., Rus. Cardiol. J. 4(66) (2007).
- [22] S.N. Samsonov, P.G. Petrova, V.D. Sokolov, A.A. Strelalovskaya et al., J. of Neurol. and Psychiatry S.S. Korsakov 14 (2005).