

## Impact of heliogeophysical factors on the clinical-biochemical indices in pregnant women

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The influence of heliogeophysical factors on the clinical and biochemical parameters of pregnant women with easy and complicated births was studied. The influence of the events of the current day and the previous solar and geomagnetic activity on clinical and biochemical parameters of pregnant women with normal and complicated births was revealed. 164 pregnant women aged from 17 to 44 years, living in Barnaul, Altai region, were examined. According to the type of delivery two groups of women were identified: 1) women with easy birth (46 people), 2) women with complicated birth (118 people). The following indicators were used to estimate the level of solar and geomagnetic activity: the number of sunspots, the number of Wolff, radiation at a wavelength of 10.7 cm, the average daily magnetic field perturbation ( $A_p$ - index), and the local geomagnetic disturbance index ( $A_k$  - index). Pregnant women were examined using the following parameters: the number of erythrocytes, leukocytes, blood platelets, leukocyte count, clotting time, erythrocyte sedimentation rate, prothrombin index, hemoglobin, sugar, fibrinogen, bilirubin (direct, indirect and total), total blood protein, and specific gravity. It has been established that the influence of heliogeophysical factors consists of immediate and delayed reactions with different latent periods: among women with normal births the most significant events are the events of the current day, as well as the 3rd, 6th and 7th days before the examination; among women with difficult births - on the 2nd, 4th, 5th and 7th days.

Among heliogeophysical factors the average daily disturbance of the Earth's magnetic field has the greatest influence on clinical and biochemical parameters. 60% of the clinical and biochemical parameters analyzed among pregnant women depend on this factor. Clinical and biochemical indicators are less susceptible to heliogeophysical factors among women with complicated births. The coefficient of determination by the factors of solar activity reaches 25% (direct bilirubin) among them; factors of geomagnetic activity - 31.5% (urine protein), whereas in the group of women with normal births the coefficient of determination is 50% (total bilirubin) and 71% (total bilirubin). According to clinical-biochemical indicators 8 types of correlations were found: 1 type - at low level of solar and geomagnetic activity, 4 types - at medium and 3 types at high level. Linear and nonlinear functional dependencies of the indicators on heliogeophysical factors are revealed for each typological group.

**Key words:** solar activity, geomagnetic activity, reproductive system, pregnancy, clinical and biochemical parameters.

### Introduction

The problem of impact of heliogeophysical factors on the functional state of the person has been relevant for many decades and is a subject of intense research (Chizhevsky, Shishina, 1969; Nikberg, 1986; Aghajanian and others, 2001, and many others). The influence factors of solar and geomagnetic activity on the embryogenesis and psychophysiological state of human development disaster of the cardiovascular system have been proved by many scientists (Khasnulin, 1992; Grigoriev, Horseva 2001, Treasurers, Trofimov, 2005; Sevastyanov et al., 2007; Samsonov et al., 2008; Botoeva et al., 2013; Bobina et al., 2016; Usenko et al., 2017; Vencloviene et al., 2014; Stoupel, 2016; Scholkmann et al., 2016). There are facts that prove that the reproductive system of women is also very sensitive to the effects of environmental factors (Mazurin and others, 1990; Ivleva, 2003; Konovalova, Konkieva, 2005) including heliogeophysical, especially during pregnancy and childbirth (Vernickay et al., 1988; Osipova and others, 2016; Helle, 2009; Skjærvø et al., 2015).

However, this issue hasn't been still researched properly, as the study of the influence of heliogeophysical factors on man faces serious difficulties. Though the influence of them is quite obvious, the results of such studies are not proved scientifically and often have a multidirectional character. It is difficult to differentiate properly the influence of the heliogeophysical factors from the accompanying influences of weather factors and phases of the lunar cycle.

The difficulty of such studies is that the effects of the factors studied become apparent both in a rapid (short latent) action and in the launch of biological reactions that appear in several days after the changes in the sun. Therefore, the observation of the current day may contain a manifestation of the influence that was previously rendered. In addition, nonlinearity and multifactoriness are specific for most of the interrelations, which requires the use of adequate analysis methods (Andronova et al., 1982).

Thus, the purpose of our work is to study the influence of the events of the current day and the previous solar and geomagnetic activity on the clinical and biochemical parameters of pregnant women with normal and complicated births.

## Materials and methods

164 pregnant women aged from 17 to 44 years (an average of  $24,3 \pm 0,4$  years) living in Barnaul, Altai region were examined. The majority of the examined were primiparous women (78%). The share of women giving birth for the second time is 16%; women giving birth for the third and more times – 6%. According to the results, two groups of women were identified: 1) women with easy birth (46 people); 2) women with complicated birth (118 people).

The number of sunspots, the Wolf number, radiation at 10.7 cm, the average daily magnetic field perturbation ( $A_p$  – index), the local geomagnetic disturbance index ( $A_k$  – index) (Dubov, Khromova, 1992) were used to estimate the level of solar and geomagnetic activity. Information about heliogeophysical factors was obtained from the monthly bulletins Solar Geophysical Data NOAA USA (<http://spidr.ngdc.noaa.gov>).

Among pregnant women the number of erythrocytes, leukocytes, blood platelets, leukocyte formula, clotting time, ESR, prothrombin index, hemoglobin, sugar, fibrinogen, bilirubin (direct, indirect and total), total blood protein, specific gravity and urine protein were determined. The data of the results of clinical and laboratory examination are correlated with the indices of solar and geomagnetic activity of the present day and of the week before the survey.

Statistical processing of the received data was carried out using Microsoft Excel 7.0 and Statistica 6.0 (Borovikov, 2003). Methods of descriptive statistics, correlation analysis (calculation of the correlation coefficient, correlation ratio and determination coefficient), k-means cluster analysis were used. The reliability of differences between the mean values of the groups was estimated using the Student's t-criterion.

## Results and discussion

It was found that clinical and biochemical indicators of pregnant women have linear and nonlinear correlations with heliogeophysical factors for a day and for 7 days before the examination. Days when the maximum values of correlation coefficients and correlation ratios of the investigated indicators with the heliogeophysical factors vary in both groups. Among women with normal birth the greatest number of maximal correlations of clinical and biochemical indices is observed with the factors of solar activity on the day of examination, and also on the sixth and seventh days before the examination, in the group of women with complicated birth – on the second and seventh days before the examination ( $p < 0,05$ ;  $p < 0,01$ ) (Table 1).

Table 1. The number of maximum correlations between clinical and biochemical parameters and heliogeophysical factors in groups of pregnant women

Heliogeophysical factor	Group	The number of maximum correlations days preceding the survey							Day of examination
		7 th	6th	5th	4th	3th	2th	1th	
<i>factors of solar activity</i>									
The number of sunspots	norm	3		2	1	2			4
	pathology	4	1		1	3	4	3	1
Wolf number	norm	1	3			1	2		4
	pathology	2			1	1	3	2	3
Radiation at 10.7 cm	norm	2	5			1	2	1	6
	pathology	2	1	1	1	1	2	2	2
<i>geomagnetic activity factors</i>									
$A_p$ – index	norm	3			3	4	2		4
	pathology		2	4	3	1	1	2	
$A_k$ – index	norm	4							
	pathology			3	2	1	1	2	4

The greatest number of maximum correlations with geophysical indices in the group of women with normal birth is observed on the 3rd and 7th days before the examination, in the group of women with complicated childbirth – on the 4th and 5th days. The maximum correlation values with geophysical data are not identified in the period of 6 days before the examination in the group of women with normal birth and of 7 days in the group of women with complicated delivery.

Three groups of clinical and biochemical indices are distinguished: high-reactivity (correlations between all heliogeophysical factors), medium-reactive (correlations with individual factors), areactive (do not have reliable correlations with any of the factors considered). Among women with normal and complicated births direct bilirubin of blood is highly reactive to the factors of solar activity whereas the number of platelets is areactive. The level of direct bilirubin and the number of leukocytes and eosinophils are also highly reactive to geomagnetic factors, while the reactive ones are the time of blood coagulation and blood sugar level.

For pregnant women with normal and complicated births group combinations of high, medium, and areactive indices are characteristic. Moreover, indicator can be highly reactive in one group and reactive with respect to heliogeophysical factors in the other group.

On average, the degree of determination of clinical and biochemical parameters of pregnant women with solar activity factors varies in the group of women with normal birth from 5% (erythrocytes) to 50% (total bilirubin), in the group of women with complicated childbirth - from 1% (blood sugar) to 25% (direct bilirubin). The degree of determination with factors of geomagnetic activity varies in the group of women with easy delivery from 7% (stab neutrophils) to 71% (total bilirubin), in the group of women with pathologies in childbirth – from 2% (prothrombin index) to 31.5% (a protein of urine).

The analysis of the results showed that pregnant women whose deliveries had complications were less sensitive to the action of heliogeophysical factors compared to pregnant women with normal births. This may be due to the fact that pathology causes decrease of adaptive potential, while the reduced reactivity is not a sign of increased resistance, but of reduced adaptability. Reduced reactivity to heliogeophysical factors can be explained by a violation in functional systems and a decrease in their reactivity to environmental factors, a nonlinear character of summation of stress due to pathology and stressing by environmental factors.

It was found that among pregnant women with complicated and normal births the same number of clinical and biochemical indices have correlations with the Wolf number and the  $A_p$ -index. The  $A_p$ -index is characterized by the greatest number of dependencies in both groups of pregnant women (Figure 1). With radiation at a wavelength of 10.7 cm in the group of women without complications in childbirth, a higher percentage of indicators with correlation dependencies is noted.

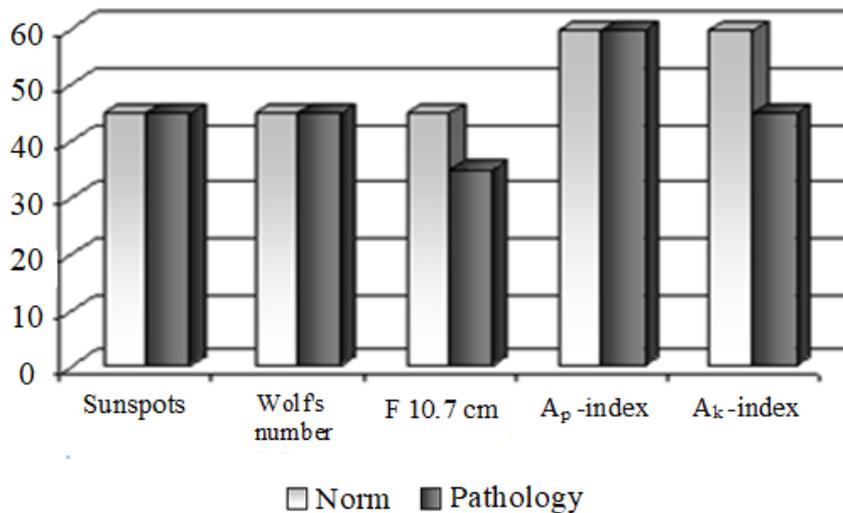


Fig. 1. The number of clinical and biochemical indicators showing correlations between factors of solar and geomagnetic activity in groups of pregnant women

A multidimensional analysis was used to identify types of reaction on the level of solar and geomagnetic activity in groups of pregnant women. It helps to identify groups using not only one or several indicators, but also their combinations. The leading indicators are averaged values of heliogeophysical indicators of the day of the survey and of seven days before the study. The calculation of statistically significant differences between clusters based on the average values of clinical and biochemical indices indicates that the greatest number of differences is better observed when all pregnant women are divided into eight clusters (Table 2).

Table 2. The results of alternate clustering of pregnant women (n = 164) with 4 heliogeophysical indicators, 18 clinical and biochemical indicators

Number of clusters	The number of significant differences between the indicators at different significance levels			
	$p \leq 0,05$	$p \leq 0,01$	$p \leq 0,001$	сумма
2	1	0	0	1
3	6	0	2	8
4	7	1	2	10
5	9	5	4	18
6	21	20	24	65
7	38	30	15	83
8	50	45	19	114
9	37	32	11	80

Clusters were ranked according to the increase in the indices of solar and geomagnetic activity. So cluster 1 includes pregnant women who were surveyed during the period with low level of solar and geomagnetic activity, and cluster VIII – pregnant women who were surveyed during the period with the highest level (Fig. 2).

During the period of the research heliogeophysical factors were fluctuating within rather wide range of limits, therefore eight clusters were divided into 3 groups depending on the level of solar and geomagnetic activity: 1 group with low solar and geomagnetic activity includes 1 cluster, 2 group with average solar and geomagnetic activity includes 4 clusters, 3 group with high solar and geomagnetic activity includes 3 clusters.

Each group is characterized by an individual set of maximum and minimum k-average values of clinical and biochemical indicators. For the group with low solar and geomagnetic activity, the min / max ratio is 0/2. For the group with an average level of solar and geomagnetic activity, this ratio varies (1/2 - cluster V, 2/5 – cluster IV, 3 / 1- cluster III, 3/3 - cluster II). For the group

with a high level of solar and geomagnetic activity, the min / max ratio is also unstable (2/2 – cluster VI, 3/3 – cluster VII, 5/1 – cluster VIII). For each cluster k-averages are calculated for all clinical and laboratory parameters.

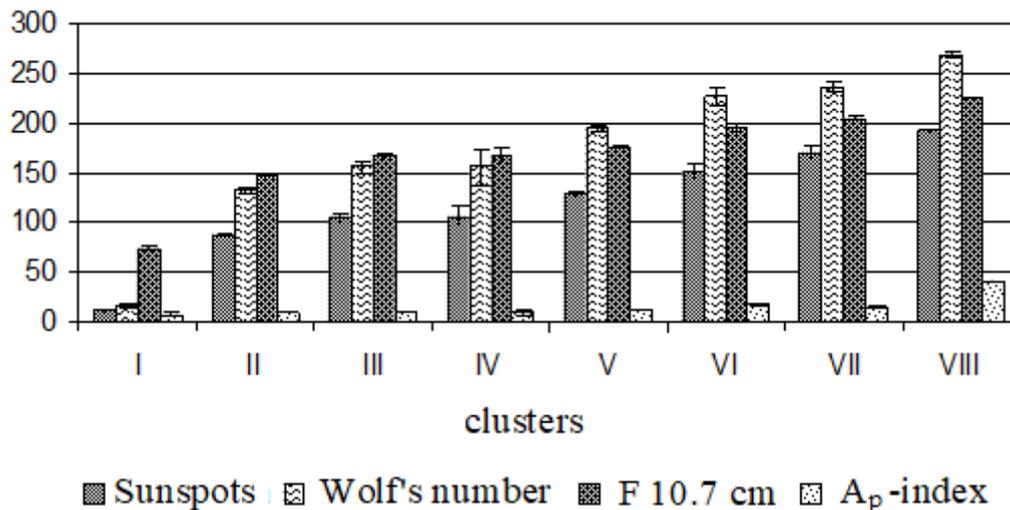


Fig. 2. Distribution of indicators of solar and geomagnetic activity in ascending order in clusters of pregnant women by clinical and biochemical indicators

It was found that pregnant women, examined during the period of low solar and geomagnetic activity, in 94% of cases have the average values of clinical and biochemical indices, but the highest levels of fibrinogen ( $4,78 \pm 0,14$  g/l), blood sugar ( $4,05 \pm 0,10$  mol/l) and the content of eosinophils ( $1,54 \pm 0,19\%$ ).

Among the women surveyed during the period of average solar and geomagnetic activity, four types were identified. The first type is characterized by a high leukocyte count ( $7,57 \pm 0,33 \cdot 10^9$  in 1 liter), stab neutrophils ( $1,82 \pm 0,17\%$ ) and monocytes ( $3,51 \pm 0,78\%$ ), low total ( $8,96 \pm 0,21$  mol/l), direct ( $1,08 \pm 0,02$  mol/l) and indirect ( $7,88 \pm 0,20$  mol/l) bilirubin in the blood. The second type is characterized by a low level of hemoglobin ( $102,27 \pm 2,45$  g/l), fibrinogen ( $3,91 \pm 0,16$  g/l), low red blood cell content ( $3,11 \pm 0,06 \cdot 10^{12}$  in 1 liter), the largest content of eosinophils ( $1,46 \pm 0,22\%$ ) in the blood. For the third type the following changes are specific: low content of leukocytes in the blood ( $5,82 \pm 0,38 \cdot 10^9$  in 1 liter) and monocytes ( $2,17 \pm 0,31\%$ ), high prothrombin index ( $93,67 \pm 2,28\%$ ) and bilirubin (direct –  $2,30 \pm 0,17$  mol/l, indirect –  $18,23 \pm 2,63$  mol/l, total –  $20,53 \pm 2,77$  mol/l), high content of segmented neutrophils ( $72,00 \pm 1,91\%$ ). The fourth type is characterized by a high level of hemoglobin ( $121,97 \pm 1,13$  g/l), a high erythrocyte content ( $3,70 \pm 0,04 \cdot 10^{12}$  in 1 liter) and a low prothrombin index ( $88,00 \pm 1,27\%$ ).

Among the pregnant women examined during the period with high solar and geomagnetic activity, three types were identified. The first type is characterized by a low level of ESR ( $28,75 \pm 2,05$  mm/h) and a prothrombin index ( $88,00 \pm 1,70\%$ ), high platelet counts ( $197,27 \pm 7,15$  thousand in 1 liter) and the time of blood coagulation ( $276,67 \pm 10,54$  s). The second type shows high ESR values ( $44,20 \pm 4,26$  mm h), high content of lymphocytes ( $33,60 \pm 3,41\%$ ) and total serum protein ( $72,62 \pm 4,37$  g/l), low content of eosinophils ( $0,60 \pm 0,24\%$ ), stab ( $0,40 \pm 0,40\%$ ) and segmented ( $63,00 \pm 2,88\%$ ) neutrophils. The third type presents low platelet count ( $176,67 \pm 3,33$  th. in 1 liter), lymphocytes ( $23,17 \pm 2,01\%$ ), the clotting time ( $214,50 \pm 16,5$  with ), total whey protein content ( $65,70 \pm 1,29$  g/l) and sugar ( $3,63 \pm 0,07$  mol/l), but a high number of leukocytes ( $7,57 \pm 0,71 \cdot 10^9$  in 1 liter) in the blood.

Thus, different diametrically opposed combinations of clinical and biochemical indicators are distinguished among pregnant women, examined at similar levels of solar and geomagnetic activity.

## Conclusions

The influence of heliogeophysical factors consists of immediate and delayed reactions during different latency periods: among women with normal births the most significant effect is on the events of the current day, and also on the 3rd, 6th and 7th days before the examination; among women with complications of labor - on the 2nd, 4th, 5th and 7th days.

Among heliogeophysical factors, the average daily disturbance of the Earth's magnetic field has the greatest influence on clinical and biochemical parameters. 60% of the parameters depend on this factor in pregnant women with normal and complicated births.

Clinical and biochemical indicators are less susceptible to heliogeophysical factors among women with complicated births than women with normal births. The coefficient of determination with solar activity factors reaches 25% (direct bilirubin); with factors of geomagnetic activity – 31,5% (urine protein).

In the group of women with normal births the coefficient of determination with solar activity factors reaches 50% (total bilirubin), with geomagnetic activity factors – 71% (total bilirubin).

According to clinical-biochemical indicators 8 types of correlations were found among pregnant women: 1 type – at a low level of solar and geomagnetic activity, 4 types – at a medium level and 3 types – at a high level. Thus, linear and nonlinear functional correlations between indicators and heliogeophysical factors are revealed for each group.

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