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On connection between hard cosmic ray flux, atmospheric pressure variation and the leaps of cardiovascular diseases in Vilnius in 2002

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The aim of the study is an investigation of prognostic relationship among the hard cosmic ray flux (HCRF), atmospheric pressure variation and the leaps of cardiovascular diseases (CVD) in Vilnius in 2002.

Materials and methods. The gamma spectrometer with scintillation detector is used to measure HCRF near the ground surface. Every measurement takes 15 min. It means that the data of over 35000 measurements is analyzed. The obtained results are registered by computer. The detailed information on meteorological situations was presented by the Lithuanian Hydrometeorological Service, and the data of CVD were taken into consideration in accordance with the number of ambulance calls. The analysis of leaps in CVD of patients of all ages was carried out.

Results. The processing of experimental data requires choosing the empirical criteria in analysis of HCRF, CVD and atmospheric pressure change in 2002, i. e. in the year of the Sun's high activity. The main criterion in HCRF change is a decrease in HCRF values of 200 impulses and more during a 4-hour time period. The minimum decrease in the atmospheric pressure of 4 hPa was considered as a change effect. The CVD number exceeding the monthly average value by 10, 15, 20% was analyzed. A correlation among the above parameters was studied in the range of 3-day period only. The efficiency of prognosis of CVD leaps by HCRF decrease in 1–2 days is 55–58%, and in 2–3 days is 64–73%. The results obtained present lack of correlation between the above mentioned parameters and the atmospheric pressure decrease because of its low number of occurrences (19–35%).

Moreover, the human factor provoking the leaps in CVD was taken into account. The majority of CVD leaps occurred in the first part of the week. There are situations when the variations of HCRF have no necessary criteria, however, the number of CVD decreases. These situations are typical to summer time.

Conclusions. It has been proved that HCRF variations can be used as an indirect indicator of geomagnetic field instability to predict the leaps in CVD in 1–3 days. The efficiency of prognosis was from 58 up to 73% in 2002. The correlation between the atmospheric pressure variations and the leaps in CVD was not found out.

Key words: hard cosmic ray flux, cardiovascular diseases, atmospheric pressure, connection

INTRODUCTION

The present situation of anthropogenic action on living organisms and people is predominant. At the same time it is necessary to take into considerations natural factors which have negative influence on people, namely: geomagnetic and meteorological processes variations, earthquakes, hurricanes and so on (1).

Variation of solar activity affects human organism by many negative factors. This act is most dangerous to people with unhealthy cardiovascular system. The main of the above factors influencing human organism turned out to be a geomagnetic field variation having an after-effect in several days (2).

The obvious consequence of geomagnetic field variation is the meteorological situation change, i. e. transfer of cyclones or anticyclones over an observation station (3). Atmospheric pressure registration is a simple process, whereas the measurement of the field geomagnetic induction is a very complicated procedure because of its small values, i. e. from a few to several hundreds nT, therefore, natural hindrances often stand out above these values.

In this case, the hard cosmic rays flux (HCRF) variations were used as an indirect indicator of the change in the geomagnetic field. HCRF is a secondary cosmic particles flux, which

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mainly consists of muons. Gamma spectrometers with a scintillation detector (NaI(Tl) crystal) were used to measure muon flux near the surface of the earth (3).

The HCRF spectrum in the range of 0.3–4.0 MeV was registered as Compton's effects (4). Measurements of HCRF were carried out continuously and the data obtained were registered every 15 min, while the results were averaged at one hour time interval.

It is known, that HCRF and meteorological processes variations are connected with the instability of solar activity and provoke a leap of cardiovascular diseases (5). The primary cosmic rays travel from the Galaxy and interact with atmospheric gases generating nuclear reactions. These reactions form new particles, pions, having the maximum concentration at the altitude of 15 km (6). The mentioned particles have a short existence time, 26 ns. It means that they can make the path of 125 m in the atmosphere and form muons with an existence time of 2 μs (6).

The muons have 100 MeV average energies and can not reach the ground surface from the altitude of 15 km either. Therefore, they reach the earth's surface from lower atmospheric layers (6). The intensive dynamic processes in the atmosphere form continuous vertical air mass motion and change the air density. These processes are connected with cyclonic or anticyclonic activity.

As a result of geomagnetic field and meteorological processes change, the flux of muons moving towards the earth's surface changes, too. Approaching an observation station, a cyclone decreases, and anticyclone increases the number of cosmic particles near the ground surface (7). Thus, an indirect factor of external influence of geomagnetic field change on human organism – HCRF variation – can be used as a prognostic indicator for changes in the number of cardiovascular diseases (CVD) cases.

The number of CVD cases was defined by the number of ambulance calls. Information on CVD was selected for all age groups in accordance with the international codes for identification of diseases (ICD). The data of the number of CVD were used for analysis. The number of CVD cases per day exceeding an average monthly level by 10%, 15% and 20 % was used as change effect. The days when the above mentioned CVD leaps were observed were taken as the basis for analysis of HCRF changes that had occurred 1–3 days before the leap in CVD incidence. Additional analysis of comparison between CVD leaps and atmospheric pressure decrease one day prior to, on the same day and one day after with regard to CVD date was carried out.

The aim of the present study is to analyze a prognostic relationship between HCRF and atmospheric pressure variation and CVD leap frequency, using HCRF as an indirect indicator of geomagnetic field variations.

MATERIALS AND METHODS

Gamma-spectrometers with a scintillation detector were used to measure HCRF. The detector was placed in the lead-protected chamber with 10–12 cm thick walls to absorb the mild component of cosmic radiation. Muons generate light micro flashes in the NaI(Tl) crystal of 6.3 × 6.3 cm size. The intensity of light's micro flash depends on the particle energy. The impulse analyzer distributed the light quanta by energies, and their number is registered by computer. Every HCRF measurement takes 15 min. Detailed HCRF measurement method has been described in (4, 8).

RESULTS

The present investigation refers to the local effects. Prognostic correlation has been analyzed in detail between HCRF and CVD variations and between CVD leaps and atmospheric pressure change.

HCRF is unstable near the earth's surface and can vary for one or several days both at individual time intervals and during all day long. These variations are a prognostic factor in CVD leaps. To get these variations right, it is necessary to find criteria for the optimum connection among the above parameters.

The HCRF value variation was studied in the 0.3–4 MeV spectrum of energies in Vilnius city to predict the leaps of CVD.

The processing of the experimental information was completed in the following way:

1. The number of cosmic particles was registered every 15 min. The obtained results were averaged up to one hour time interval.

2. A decrease in HCRF values (more than 200 impulses) during a 4-hour period was chosen to be the first criterion to predict the CVD leaps.

3. A difference of 15 impulses (in one hour interval) or more between the average daily HCRF data and previous day was chosen as the second criterion.

4. Correlation between the above mentioned HCRF decrease and an increase in CVD leaps number in 1–3 days was identified.

5. Correlation between atmospheric pressure decrease and increase in CVD number on the same day, one day before and one day after CVD leap was analyzed.

6. The influence of the human factor on CVD leaps was taken into consideration.

The results of average monthly value produce analogical curves course of HCRF and CVD with maximum in winter and minimum in summer time (Fig. 1, curves 1, 2). However, the average monthly values of atmosphere pressure course are different (Fig., curve 3). Thus, the average monthly values correlation course is specific to HCRF and CVD; however, it is unavailable for atmosphere pressure (Fig.).

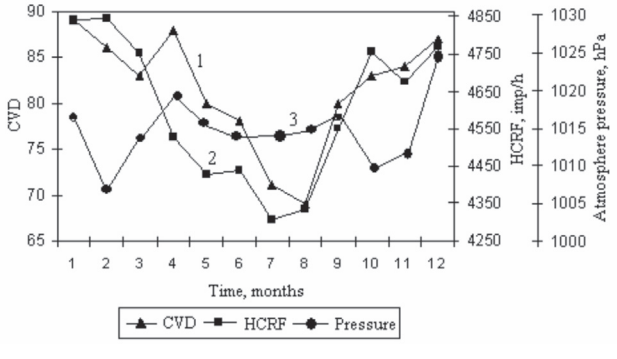

Fig. Average monthly values in Vilnius in 2002: 1 – cardiovascular diseases; 2 – hard cosmic ray flux; 3 – atmosphere pressure

Correlation between HCRF and CVD variation was analyzed in detail, using the above mentioned criteria one or two (9). It is natural, that most prognostic effect was achieved using two criteria.

A high prognostic efficiency of CVD leaps by HCRF decrease over a 4-hour time period and more was only the first criterion. However, analysis of the same results, using the second criterion (days with a difference of 15 or more impulses between the average daily HCRF data and previous day) shows, that prognosis in a leap of CVD was unrealized many times in 1–3 days after HCRF decrease. Thus, the second criterion may be only an additional parameter while analyzing the above connection. It means that the second criterion for prognosis of leaps of CVD cases by HCRF decrease is unsatisfactory. Therefore, to define a correlation between HCRF variations and the number of CVD leaps, the first criterion was used. The results obtained are presented in Table 1.

According to the data of Table 1, the efficiency of prognosis of CVD leaps by HCRF decrease in 1–2 days is 55–58%, while in 2–3 days amounts to 64–73%. The most effective prognosis of the number of CVD leaps was in 2–3 days after HCRF decrease, when the CVD number exceeded the average monthly value by 20% in 2002. A similar comparison was carried out between the number of CVD leaps and the decrease of atmosphere pressure on the same day, one day before and one day after. The criterion of atmosphere pressure decrease was 4 hPa and more. The results obtained are presented in Table 2.

The data of Table 2 illustrate the lack of correlation between CVD leaps and atmosphere pressure decrease, because the efficiency of occurrence is from 19 to 35%.

The results presented in Table 2 confirm the fact that atmosphere pressure variations do not influence the leaps of CVD. This connection can be only of occasional character.

After analysing the correlation of the above-mentioned parameters, it is necessary to consider another phenomenon, human factor, provoking leaps in CVD (Table 3).

The data in Table 3 illustrate the fact that the main part of CVD number was found to belong to the first half of the week.

Table 1. **CVD numbers exceeding the monthly average values by 10%, 15%, 20% in 1–3 days in 2002 and the number of occurrences by HCRF variations**

Months	CVD number of the average monthly value			Number of occurrences					
				in 1–2 days intervals			in 2–3 days intervals		
	10%	15%	20%	10%	15%	20%	10%	15%	20%
January	7	3	2	6	3	2	6	3	2
February	6	4	3	3	1	0	3	1	1
March	8	6	2	4	3	2	3	2	2
April	7	4	0	5	3	0	5	3	0
May	9	8	2	5	4	2	6	6	1
June	8	5	3	4	2	1	6	4	2
July	10	6	5	5	3	2	5	4	3
August	12	8	2	9	6	2	10	7	2
September	9	5	1	3	2	1	3	2	1
October	7	5	2	6	4	1	4	3	1
November	7	5	2	3	2	1	5	3	2
December	7	3	2	3	1	1	6	3	2
Total	97	62	26	56	34	15	62	41	19
Total, %				58	55	58	64	66	73

Table 2. **CVD numbers exceeding the monthly average values by 10%, 15%, 20% and the number of atmosphere pressure decrease (decrease of 4 hPa and more) in Vilnius in 2002**

Months	CVD number of the average monthly value			Number of occurrences								
				1 day before			On the same day			1 day after		
	10%	15%	20%	10%	15%	20%	10%	15%	20%	10%	15%	20%
January	6	3	2	1	1	1	0	0	0	2	1	0
February	7	4	3	3	2	1	3	3	3	3	1	1
March	8	6	2	1	1	1	1	1	1	2	1	0
April	7	4	0	1	0	0	4	2	0	5	3	0
May	9	8	2	1	1	0	2	2	1	3	3	1
June	8	5	3	1	0	0	2	2	2	2	2	1
July	10	6	5	0	0	0	0	0	0	1	1	1
August	12	8	2	1	0	0	0	0	0	0	0	0
September	9	5	1	2	2	1	1	0	0	3	2	0
October	7	5	2	5	4	2	1	1	0	2	1	1
November	7	5	2	2	1	1	1	1	1	2	0	0
December	7	3	2	3	1	1	3	1	1	2	0	0
Total	97	62	26	21	13	8	18	13	9	27	15	5
Total, %				22	21	27	19	21	35	28	24	19

Table 3. **Dependence of CVD numbers exceeding the monthly average values by 15%, 20% on days of the week in 2002**

Days of the week	Number of leaps of cardiovascular diseases that exceeds the monthly average	
	15%	20%
Monday	16	7
Thursday	13	7
Wednesday	12	2
Thursday	11	6
Friday	5	2
Saturday	1	0
Sunday	4	2

These facts are confirmed in papers (9, 10). There are situations, in which variations of HCRF do not have a necessary criterion, however, the number of CVD decreases. These situations are typical of summer time.

DISCUSSION

This investigation pioneered the comparison of three parameters variation, i. e. HCRF, CVD and atmosphere pressure. The connection of these parameters variation was assessed, and the optimum criteria of its study were proposed. It was determined that in order to analyze the prognostic cases of CVD leaps, various methods have to be used. While analyzing the results obtained it is possible to use two criteria for variation of HCRF. In this case the efficiency of prognosis of CVD leaps is growing only by 7%. Using only the second criterion (where a difference of 15 or more impulses between the average daily HCRF data and the previous days) a lot of prognostic results are unrealized, thus, the first criterion was used only for the prognosis of CVD leaps, as it has lower efficiency, but higher reliability.

CONCLUSIONS

1. It has been proved that for the prognosis of the number of cardiovascular diseases by variations of HCRF only one criterion can be used – a decrease in HCRF values for a 4 h period and more.

2. The efficiency of prognosis of the number of CDV cases exceeding the monthly average by 10% was 58–64%, while that by 20% made up to 58–73% in 2002.

3. The efficiency of prognosis between the atmospheric pressure decrease and CVD leaps on the same day, one day before and one day after was not determined.

4. Increase in the CVD case number in excess of 20% of the average monthly value was about 50% in stable weather.

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RYŠIO TARP KIETOSIOS KOSMINĖS SPINDULIUOTĖS SRAUTO, ATMOSFEROS SLĖGIO IR ŠIRDIES BEI KRAUJAGYSLIŲ LIGŲ PAIEŠKA VILNIAUS MIESTE 2002 M.

Santrauka

Darbo tikslas – ištirti ryšį tarp kietosios kosminės spinduliuotės srauto (KKSS), atmosferos slėgio svyravimų bei širdies ir kraujagyslių ligų (ŠKL) paūmėjimo Vilniaus mieste 2002 metais.

Medžiagos ir metodai. Prie Žemės paviršiaus KKSS buvo matuotas gama spektrometru su scintiliaciniu jutikliu. Kiekvienas bandymas truko 15 minučių. Atlikta 35000 bandymų rezultatų analizė, gauti rezultatai užregistruoti kompiuteriu. Išsamią meteorologinę informaciją pateikė Lietuvos hidrometeorologijos tarnyba. Remiantis greitosios pagalbos iškvietimų skaičiumi, buvo atlikta įvairaus amžiaus žmonių ŠKL paūmėjimų analizė.

Rezultatai. Norint atlikti KKSS, ŠKL ir atmosferos slėgio analizę, būtina parinkti atitinkamus empirinius kriterijus. Analizei pasirinkti 2002 m. rezultatai, kai Saulės aktyvumas buvo aukštas. KKSS

svyravimų pagrindiniu kriterijumi pasiūlytas KKSS 200 impulsų ir daugiau mažėjimas per 4 valandas. Atmosferos slėgio pokyčio efektu laikomas jo mažėjimas nuo 4 hPa. Reikšmingas ŠKL paūmėjimas laikomas tuomet, kai vidutinė mėnesio reikšmė viršijama 10, 15, 20%. Koreliacija tarp minėtų parametrų buvo tiriama trijų parų laikotarpiu. ŠKL paūmėjimų prognozės efektyvumas pagal KKSS variacijas po 1–2 parų siekė 55–58%, o po 2–3 parų – 64–73%. Nerasta koreliacijos tarp minėtų parametrų ir atmosferos slėgio, nes prognostinis efektas sudarė 19–35 %.

Dauguma paūmėjimų nustatyta pirmą savaitės pusę. Būta atvejų, kai KKSS svyravimai nesiekė empirinio kriterijaus, o ŠKL skaičius mažėjo. Tokios situacijos būdingos vasarai.

Išvados. ŠKL paūmėjimų prognozei po 1–3 parų galima taikyti KKSS variacijų duomenis kaip geomagnetinio lauko nestabilumo netiesioginį indikatorių.

2002 m. prognozės efektyvumas buvo nuo 58 iki 73%. Nerasta koreliacijos tarp atmosferos slėgio variacijų ir ŠKL paūmėjimų.

Raktažodžiai: kietosios kosminės spinduliuotės srautas, širdies bei kraujagyslių ligos, atmosferos slėgis, ryšys