CORRELATION RELATIONS BETWEEN PULSE AND BLOOD PRESSURE AS A CHARACTERISTIC OF THE PATIENT'S CONDITION

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Abstract: *Usually the patient's condition is assessed by blood pressure values and heart rate. In previous works by the authors, the emphasis was on the analysis of long-period component of the series under study and their connection with geophysical / atmospheric phenomena. This work describes the patient's condition through the correlation of blood pressure and heart rate and, classifying assess the role of external factors in these "coordinates". Examines the correlation in the moments of the lunar apogee and perigee.*

The material for the study is the blood pressure and pulse readings taken from the patient's self-monitoring diary. Since April 1997, after outpatient treatment, daily (morning and evening) monitoring of blood pressure at home under the supervision of a doctor is carried out. Long-term and effective monitoring (more than 18 years) ensures the normal functioning of the patient and allows you to study the influence of external factors on the state of the body.

ХАРАКТЕРИСТИКА СОСТОЯНИЯ ПАЦИЕНТА ЧЕРЕЗ КОРРЕЛЯЦИОННЫЕ СВЯЗИ ПУЛЬСА С АРТЕРИАЛЬНЫМ ДАВЛЕНИЕМ

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Резюме: *Обычно состояние пациента оценивают по значениям артериального давления и пульса. Так как их величины достаточно изменчивы, то в предыдущих работах авторов упор делался на анализ длиннопериодных компонент исследуемых рядов и их связи с геофизическими / атмосферными явлениями. Данная работа предлагает описывать состояния пациента через корреляционные связи показаний артериального давления и пульса, классифицируя их, оценивать роль внешних факторов в этих «координатах». Исследуются корреляционные связи в моменты лунного апогея и перигея.*

Материалом для исследования служат показания артериального давления и пульса, взятые из дневника самоконтроля пациента. С апреля 1997 г., после проведенного амбулаторного лечения, осуществляется ежедневный (утром и вечером) контроль за артериальным давлением в домашних условиях под наблюдением врача. Длительный и эффективный контроль (более 18 лет) обеспечивает нормальную жизнедеятельность пациента и позволяет исследовать влияние внешних факторов на состояние организма.

Introduction

When assessing the patient's condition, it should be primarily based on indications of the blood pressure (BP) and pulse - heart rate (HR). Since their values are quite variable, there is no clear functional relationship between the BP and HR values. Slow pulse does not mean low blood pressure. And with a high pulse, the pressure can be not only normal, but also in some cases it is reduced (in

case of myocardial infarction or heart failure), because the high frequency of heart contractions does not leave the heart enough time to collect enough blood amount and such work will be ineffective. Based on long-term observations, it is possible to assess the nature and dynamics of the heart rate connection with the patient's pressure. The article [1] analyzed long-term observations of a number of physiological parameters (including pulse with blood pressure) of the eight subjects and emphasized the importance of such studies, although isolated cases. We share this view and make our contribution.

In the paper of the authors [2], an array of situations is presented where the connection between HR and BP can be compared with the patient's behavior or the manifestation of external conditions. During periods of increased activity (business trips, holidays, etc.), the pulse and BP could be increased. The moments of atmospheric pressure deviation from the annual average by more than ± 15 mm Hg are also considered. BP and HR variations are less pronounced on these days than when activity is increased, but the sign of variations in morning pulse and BP values coincides with the sign of variations in atmospheric pressure. The authors [3] in their earlier paper noted the manifestation of the ~ 27.35 days "lunar" period in the range of morning values.

This work describes and classifies the patient's condition through the correlations of the BP and HR values. The correlations at the lunar apogee and perigee moments are investigated.

Classification of heart rate and ABP correlations

A twelve-year interval (2000-2011, total 4383 days) was selected from long-term observations under the self-control of ABP program [2, 3]. This is an interval with more active patient behavior and stable pulse readings, SBP and DBP – systolic and diastolic blood pressure (from the pulse pressure analysis [4]). To describe the degree of coordination of the body and the comparison with the baseline characteristics it is reasonable use of the time dependence of the coefficients of linear correlation of medical parameters. In the time interval dT, for the corresponding fragments of series A and B, the linear correlation coefficient r = Corr(A&B/dT) is calculated. Scanning interval of dT along the time axis and finding the correlation coefficient at each point in time, we obtain the temporal dynamics of this factor r(t) – Corr(A&B/dT; t). With this approach, the entire variety of situations is mapped onto the interval of [-1; +1] and has an estimated character of the state of the body, but the temporal dynamics and synchronism of the change in correlation coefficients, as well as the degree of their smoothness, allow one to investigate the consistency of the readings and make a comparison with the behavior of other factors.

The following is an analysis of the correlation series for morning and evening data obtained by scanning interval of 5 days, from series HR, SBP and DBP, we move to correlation series K1 ÷ K3, where: K1(t) = Corr(HR&SBP/dT; t) – dynamics of the correlation coefficient between the of heart rate and SBP; K2(t) = Corr(HR&DBP/dT; t) – the correlation between HR and DBP; K3 (t) - between SBP and DBP. Examples of the relationship of correlation series with external factors are given in [2, 4].
Now the patient's condition is associated with a triple of numbers K1÷K3, which reflects the relationship between heart rate, SBP and DBP readings.

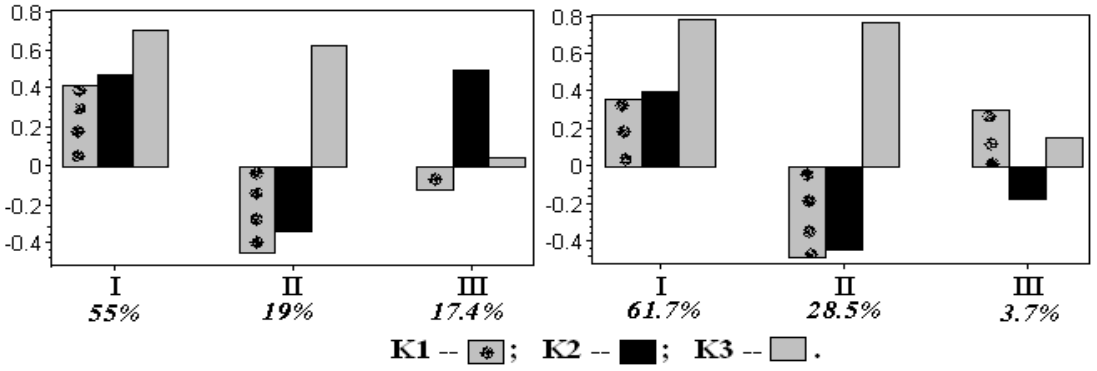

Fig. 1. The main groups of the patient's condition; the left plot - morning

Fig. 1 shows the characteristics of the three main morning and evening groups (clusters) of the patient's condition in these variables, the 0Y axis - the average values of K1 ÷ K3 for the group, several small groups are dropped ≤ 2% each.
The sizes of the three morning groups and the first two evening groups are comparable (91.4 & 90.2%), at the same time the structures of the morning and evening groups I / II are similar - the values of K1 ÷ K3 are changed slightly and the volume are changed more significantly (*55% => 61.7% ; 19% => 28.5%*).

Changes in BP (because of stress, physical exertion or other factors) are associated with changes in Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) so that their difference varies within 40-60 mm Hg, since our arteries smooth out the shear stress after cardiac output. This concordance reflects K3 in groups I and II - 74% of conditions in the morning and 90.2% in the evening. At the same time, HR changes in phase with SBP / DBP in group I and in opposite phase in group II. Also in the morning the role of group III (17.4%) with a clear connection between HR and DBP (K2>0.5) is significant in the case of SBP "random" behavior (K1, K3≈0). It was noted in [2] that the morning HR / BP values are less balanced and the body is more exposed to external influence, the morning rows have more asymmetry; the distribution of evening parameters is closer to normal (kurtosis~3) in contrast to morning parameters with kurtosis~ 4; the "lunar" component is present in the morning data. The manifestation of group III in the morning, i.e. a wider range of conditions in the morning values reflects this fact.

Time characteristics of groups

Fig. 2 demonstrates splitting of the states of groups I / II by years. The morning states of group III are decomposed on Fig. 3 by years and months.

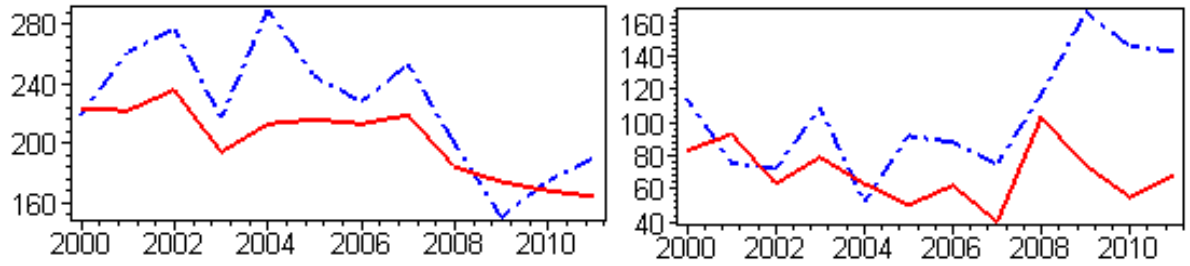

Fig. 2. Distribution of groups I (left) and II (right) readings by year.
Morning readings – solid line; evening – discontinuous.

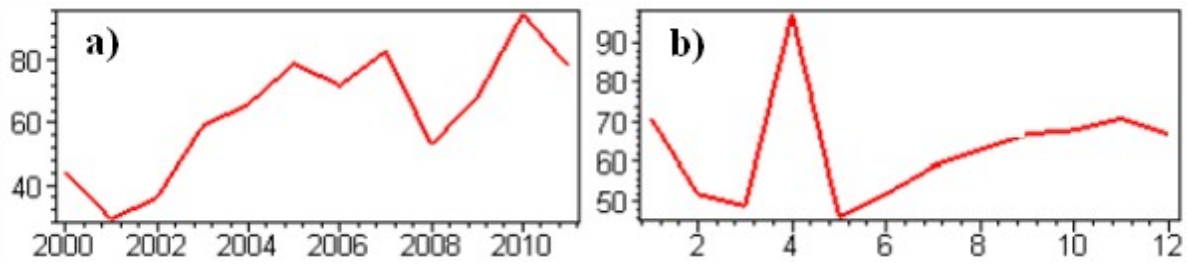

Fig. 3. Morning states of group III ; a) – distribution by year, b) – seasonal, by month

In the evening states (Fig. 2), the "transfer" over the years from group I to group II is apparent. This is also demonstrated by morning values, but with an active role of group III: I=>II, III. We can see a growing trend on Fig. 3a; Fig. 3b demonstrates the seasonal nature. A general tendency can be noted in the weakening of the links between HR/SBP/DBP and more frequent development of such situations with age. The body's sensitivity to seasonal changes is also increased. The given trends can be used to estimate the rate of these processes.

Assessment of the lunar factor by correlation series

The presence of 27.35 days harmonics in the morning values has already been noted. The presence of the variation from the gravitational effect in the morning readings is consistent with the possibility of synchronizing individual body functions with the lunar parameters [5, 6]. The allocation of the 27.32-days period in mortality and the incidence of heart attack in humans when analyzing data for 21 years is reported in the paper [7]. It is reasonable to compare fragments of correlation series at the Moon minimum and maximum distances.

Perigee/apogee was reached 159 times for 2000 ÷ 2011. Let us investigate the series K1 ÷ K3 by the epoch folding method, the zero day is the moment of perigee/apogee. On Fig. 4, the values are compared at the Moon minimum and maximum distance after sliding averaging over 3 points, the 0X axis is days. At the apogee, the connection between the pulse and SBP / DBP (K1/K2) locally weakens; at perigee we can see an increase in K1 in the morning/evening and in K2 in the evening. The splitting of states and their comparison was most clearly manifested in the K1 morning values. These results are obviously the matter of judgment (quality).

Conclusion

Such studies of long-term and regularly conducted medical observations, in spite of isolated cases, are of undoubted interest. The analysis of the dynamics of these readings both increases the effectiveness of treatment, and gives the opportunity to study the influence of external factors on the body. It is important to emphasize that fairly homogeneous series were analyzed in our case, since both time and conditions for taking daily readings were similar. Many researchers attributed the influence of the moon with its synodic period (29.5 days). In our case clearly evident sidereal moon period (27.3 days). Everyone reacts individually to the movement of the Moon. Statistical research on the effect of the Moon usually give less expressed picture than solo monitoring.

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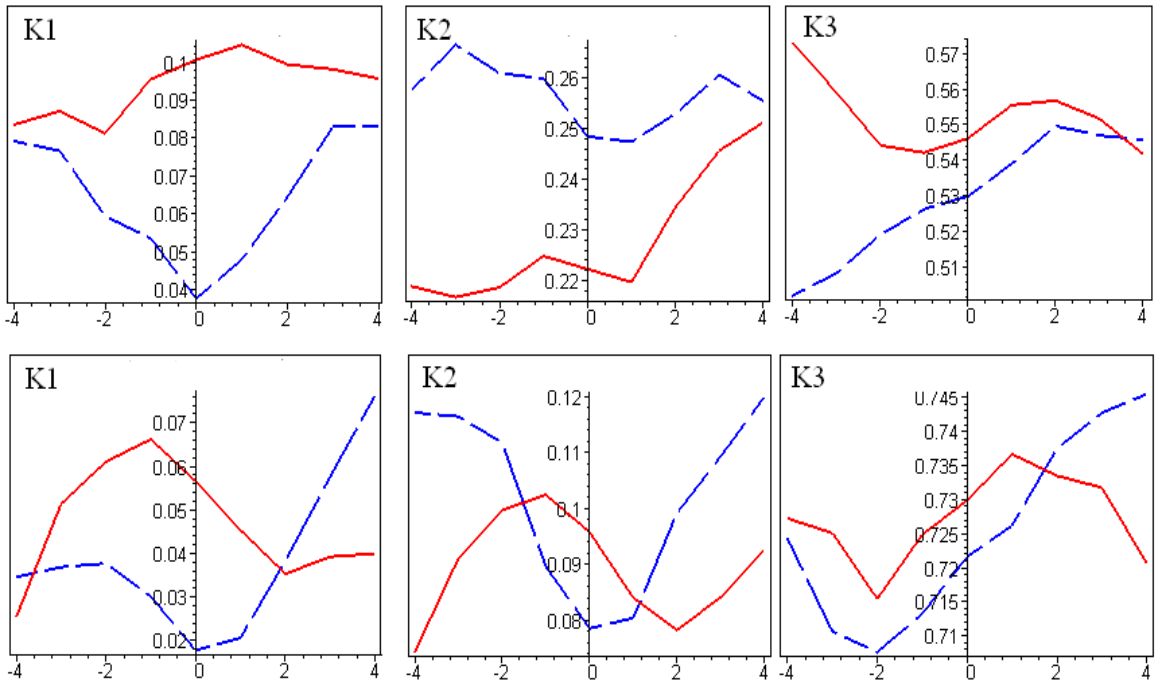

Fig. 4. Dynamics K1÷K3 in the vicinity of perigee/apogee, 0 – moment of the event; perigee–solid line, apogee–discontinuous; morning – top plot, evening - bottom

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