

Clinical Cosmobiology - Sudden Cardiac Death and Daily / Monthly Geomagnetic, Cosmic Ray and Solar Activity - the Baku Study (2003-2005)

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Part of results of collaborative studies for revealing an influence of the periodical changes of solar, geomagnetic and cosmic ray activities on the sudden cardiac death (SCD) mortality is described in this paper. The data covering daily and monthly temporal distribution of SCD (788 patients in 36 months in 2003-2005), taken from all of emergency and first medical aid stations of grand Baku area, were analyzed and compared with certain cosmophysical parameters. It was obtained that SCD is higher on the highest and lowest daily levels of geomagnetic activity. Days with SCD are accompanied by higher cosmic ray (neutron) activity. The monthly number of SCD was inversely related to solar and geomagnetic activities while was positively linked with cosmic ray activity level. It was concluded that cosmic ray activity could be considered as one of regulating external/environmental factors in human homeostasis.

Background

The technological and biological systems, including human beings, are exposed to the influence of so called space weather [1] and are very sensitive to solar and geomagnetic activity and to changes in these activities and their manifestations on the Earth [2, 3]. It is well known that the Sun as a main driver of the space weather is overwhelmingly important to life on the Earth, but most of us have not been given a proper description of solar activity variations and their negative influences on living beings. Space weather changes undoubtedly affect the geosphere, our physical environment, which in turn, influences human health and all-kind of activities of human beings [4-6]. Thus there will be continued and intensified need for research works on these effects, to address health and safety, as well as to study societal-economical impacts and to verify the existence of possible influence of space weather on biological systems.

There are series of studies in the field named "clinical cosmobiology", considering relationship between the frequency of total deaths, cardiac arrhythmias, occurrence of acute myocardial infarction, risk related cardiovascular parameters, deaths from cardiovascular diseases, temporal distribution of sudden cardiac death (SCD), stroke, life threatening cardiac arrhythmias, homicide and suicide and the level of major environmental physical (cosmophysical) activity factors. We refer reader to the review paper [7] and references herein.

Study of heart rhythm variability in various environmental physical conditions was conducted by Breus et al [4]. It was concluded that variations of natural external synchronizers, such as solar radiation and geomagnetic field fluctuations, lead to a similar response in biological systems, namely adaptive stress.

In spite of enough information about cancer, HIV/AIDS, and other diseases, there are no other diseases responsible for so many deaths each year as heart diseases and SCD. Despite recent advances in preventing, SCD from any reason is one of the leading causes of natural death, resulting in millions of adult deaths every year in the world. Most people are unaware they are at risk for the condition: it strikes without warning, and, according to the research estimations, 9 out of 10 victims die before reaching the hospital or emergency room. The victim may or may not have diagnosed heart disease. The time and mode of death are unexpected.

SCD is described as death of cardiac origin occurring in one hour time limit, without prodromes (preliminary symptoms) [8, 9]. The incidence of SCD increases with age in both men and women. SCD has a much higher incidence in men than women; about 75% of SCDs occur in men, with an annual incidence 3 to 4 times higher than in women. The peaks in incidence of SCD for adults occur between 45 and 75 years of age as a result of coronary artery disease [10]. SCD is rare in children, affecting only 1 or 2 for every 100,000 children each year. SCD in females less than sixty five years old is relatively rare.

There are many factors [8] that can place a person at risk of SCD, including: coronary artery disease (majority of SCD is linked with this disease) resulting in ventricular tachycardia, ventricular fibrillation; asystolia, pulseless electrical activity (electromechanical dissociation). Smoking; heart failure; dilated cardiomyopathy (an abnormally enlarged heart and the cause of SCD in about 10% of patients); the first 6 to 18 months after a heart attack; hypertrophic cardiomyopathy and some other conditions are related to higher risk of SCD [8-11].

SCD is influenced by seasonal and terrestrial weather changes, by variations in temperature, atmospheric pressure and other meteorological parameters.

But, alongside with above-mentioned medical-biological, meteorological, social and other affecting factors, disturbances and variations in the external/environmental physical activity can play a significant role in SCD mortality as a trigger factor.

Study of correlations between medical-biological and heliogeophysical indices bears a task of multifunctional analysis taking into account other natural and societal factors of the environment which have more intensive impact on biological objects than heliogeophysical factors. But, based on the theory of phase transition induced by the noise, which is applied in biology, we can consider the human being as a biological object, acting as an open non-linear system, being in the state of non-stable dynamic balance. Transition of this bio-system into critical state (illness, death, etc.) can happen even in the case of very weak external influence (signal) having a level of noise. Periodical and/or aperiodical changes of space weather could play a role of one of these external factors [4]. Sporadic and impulsive manifestations of solar activity can be considered as some "failures" of relatively regular rhythms of heliogeophysical factors.

In this study we considered the influence of space weather changes on SCD mortality on the basis of three-year daily medical data taken from mid-latitude geographical location. Effects of three kinds of cosmophysical activity: solar (SA), geomagnetic (GMA) and cosmic ray (CRA) were considered.

Material and methods

Environmental physical activity is one of the significant regulating forces in biology. The purpose of our collaborative and interdisciplinary study was checking possible links between daily levels of SA, GMA (with levels I0-IV0, for mid-latitudes) and CRA (neutron monitor data, imp/min on the Earth's surface), and incidence of SCD for all and for each gender separately, with agony time limit, without prodromal symptoms. SCD was assumed when a person died within 1 hour after the onset of the symptoms (it is the presently accepted time limit [9, 11]). In this group electrical heart instability is dominant and more expressed at low GMA (see: [13] and relevant references herein).

Daily medical database was created for deaths from all causes registered according to WHO standards in 22 Emergency and First Medical Aid Stations (EFMAS) spread on big urban area (the Absheron Peninsula located at mid-latitudes (40°23' N, 49°51' E), including

Baku capital city of Azerbaijan with more than 3 millions of inhabitants) as well as in the Central Emergency and First Medical Aid Station in Baku. Results of monitoring carried out as joint work in the Baku city railway polyclinic No2 and in the Research Institute for Cardiology under the Ministry of Public Health of the Republic of Azerbaijan were partially involved in these studies. It is evident that database created by the help of above-mentioned sources can not be absolutely ideal and may contain some per cent of discrepancy which in turn is admissible for population-based statistical data. This, in our opinion, does not significantly affect the general picture of the considered problem. Besides, it must be taken into account that according domestic legislative rules almost all of deaths must be registered by EFMAS services which allows considering this data as comparatively reliable.

More than 1,000,000 emergency calls were subjected to the "cleaning" from deaths due to non-cardiovascular reasons, cancer, traffic/road and other accidents, suicide, stroke, etc., and remaining data (cardiovascular related deaths) was analyzed. EFMAS services register all cases of sudden deaths accurately, including the unwitnessed ones. It is very difficult and sometimes impossible work. Even classifications based on clinical circumstances can be misleading and often impossible, because 40% of sudden deaths can be unwitnessed [10]. We relied on the final diagnosis established by EFMAS services using relevant medical and other methods.

Time span covered by the data was chosen from January 2003 to December 2005 (continuous data).

SCD data was separated from the initial data on cardiovascular related deaths in accordance to the International Classification of Diseases and Related Health Problems, 10-th revision (ICD-10, 2006), Code I46.1 (<http://www3.who.int/icd/currentversion/fr-icd.htm>).

Deaths due to diagnosed acute myocardial infarction (AMI) are not considered in this paper.

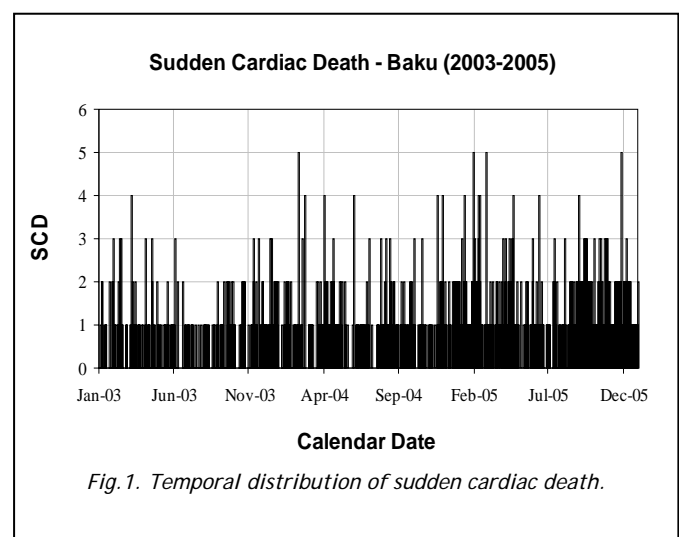


Fig. 1. Temporal distribution of sudden cardiac death.

Medical data on SCD (Fig. 1) (length of data series: T = 3 years; sampling interval: d = 1 day; months: m = 36 months; number of SCD: N = 788; limited ages of victims involved in this study: 25-80 years old; male: 666 and

female: 122) was created and analyzed together with cosmophysical data for the considered time period.

SCD is responsible for almost half of the mortality from cardiovascular disease in most developed countries. In less-developed countries (as in our case), sudden cardiac death rates parallel the rates of ischemic heart disease as a whole and therefore are lower [10]. Number of population-based studies has shown some decline in the incidence of SCD caused by coronary heart disease since the early 1980s. Thus the number 788 for SCD considered in our study looks realistic.

As we considered the period of relative economical and social stability in Azerbaijan (2003-2005), possible negative factors as a result of the occurrence of major socioeconomic changes in a newly independent country, in our opinion, did not influence so deeply the principal results of this study. Despite these changes, however, the solar and geomagnetic activity parameters were in effect all the time, and studies conducted in other parts of the Earth have revealed the existence of similar effects even in developed countries [4-6, 12, 15, 16].

Created medical data contains information about the gender and age of SCD-victims, exact time of agony/death, special remarks on death (death before or during professional medical aid), etc., which allows to conduct more detailed analysis on the considered problem. Results of these studies will be subject of another study.

The following space weather (cosmophysical) parameters were used in our studies for the same time period:

- for SA: sunspot number (SSN) and solar radio flux at 10.7 cm wavelength (F10.7);
- for GMA: Ap, Cp, and Am geomagnetic indices;
- for CRA: the neutron monitoring data on the Earth's surface.

Data for SA and GMA were obtained from the US NOAA National Geophysical Data Center (www.ngdc.noaa.gov/) and NOAA Space Environment Center, Boulder, Colorado (www.sec.noaa.gov/). CRA data was from the Moscow Cosmic Ray Station (Neutron Monitor), IZMIRAN, Russian Academy of Sciences (<http://helios.izmiran.rssi.ru/cosray/main.htm>), as well as the Oulu University, Finland (<http://cosmicrays oulu.fi/>).

Geomagnetic activity levels and their gradation are defined in the Table 1.

TABLE 1

Geomagnetic Activity Gradation

Category	"Ap" index range	Typical "Kp" values	Amplitude (nanotesla)
Quiet (I ⁰)	0 < Ap < 8	Usually No. > 3	0-20
Unsettled (II ⁰)	8 < Ap < 16	Usually No. > 3	21-40
Active (III ⁰)	16 < Ap < 30	Few indic. of 4	41-70
Minor storm (IV ⁰)	30 < Ap < 50	Mostly 4 and 5	71-120
Major storm (IV)	50 < Ap < 100	Some indices 6	121-200
Severe storm (IV)	100 < Ap	Some indices 6	201->550

Results and conclusions

Solar, geomagnetic and cosmic ray activities and their changes, as drivers of the space weather, have an influence on human health [4-7, 12-18]. Conducted in this paper research was aimed to study the nature of these influences on human homeostasis, namely, on SCD mortality in mid-latitudes.

Parametrical methods of statistical correlation analysis (i.e., Pearson method) and Student's t-test were used in our studies. Table 2 presents the results of the SCD study for all three cosmophysical parameters: SA, GMA and CRA indices. Average daily neutron activity for the considered years 2003-2005 and for days with SCD within same years are provided in the Table 3. Table 4 includes comparative data for both genders (female and male) on a daily GMA basis.

TABLE 2

Monthly (N=36) Sudden Cardiac Deaths' (SCD, N= 788) Links with Cosmophysical Activity Indices, Baku, Azerbaijan, 2003 - 2005

Parameter	Pearson correlation coefficient (r)	Probability (p)
Year	0.67	<0.0001
Months 1-12	0.135	N.S.
Sunspot Number (SSN)	-0.76	<0.0001
Smoothed SSN	-0.625	<0.0001
Solar Radio Flux (10.7cm)	-0.7	<0.0001
Adjusted Solar Radio Flux	-0.75	<0.0001
GMA index Ap	-0.43	0.008
GMA index Cp	-0.47	0.0084
GMA index Am	-0.44	0.007
Cosmic Ray - Neutron Activity (imp/min)	0.511	0.0014

TABLE 3

Average Daily Neutron Activity in Years 2003-2005 Compared with Data on Days with Sudden Cardiac Deaths (SCD, N = 788 in 523 days), Baku, Azerbaijan, 2003-2005

Average daily neutron activity (imp/min) 2003 - 2005, 1096 days	Average daily neutron activity (imp/min) on days of SCD, 523 days	Probability of difference
8475.35 ± 339.7	8538.08 ± 322.5	p=0.0003

In total 788 SCD occurred (84.5% male). Daily I0 - IV0 GMA - SCD distribution was 0.78, 0.66, 0.64 and 0.92; women were less affected by high GMA than men.

The daily CRA (Neutron) was 8475.35 ± 339.7 for the whole 3-year period, 8538.08 ± 322.5 in 523 days (Moscow data) with SCD (p = 0.0003). The daily number of SCD was 1-5. At days with 4-5 SCDs (n=16) the CRA was 8657.5 ± 189 (compared with all 1096 days, p = 0.00018, with 523 days with SCD (1-5) – p = 0.016).

Comparison of the monthly SCD data revealed a significant and inverse correlation with SA indices ($r = -0.625 \div -0.76$, $p < 0.0001$) and with GMA indices ($r = -0.43 \div -0.47$, $p = 0.007 \div 0.0084$). A positive correlation was found for year of study and Cosmic Ray (Neutron) Activity ($r = 0.511$, $p = 0.0014$).

TABLE 4

Daily Geomagnetic Activity (GMA) and Sudden Cardiac Deaths (SCD, N = 788), Baku, Azerbaijan, 2003 - 2005

SCD \ GMA	I ⁰	II ⁰	III ⁰	IV ⁰	All
Total	369	267	118	34	788
%	46.8	33.88	14.97	4.31	100
Male	305	230	101	30	666
%	45.8	34.5	15.16	4.5	100
Female	64	37	17	4	122
%	52.45	30.3	13.9	3.27	100
Total days in 2003 - 2005	473	401	185	37	1096
%	43.16	36.5	16.94	3.4	100
SCD/daily	0.78	0.66	0.64	0.92	-

The possible biological mechanisms of the multidirectional effects of the considered cosmophysical factors (SA, GMA and CRA) on humans have not been yet established but they show correlation with many medical events, having behavioral, laboratory, pathological and other aspects.

Limitation of the study: the high number of unwitnessed deaths can in some cases affect the accepted time limits of SCD description.

It is difficult to exclude in part of included in this study SCD as consequence of acute myocardial infarction were a electrocardiogram of the still functioning heart is a principal clue for diagnosis.

Some SCD could not be reported to first aid medical institutions.

Conclusions:

- The timing of SCD shows significant relationship to space physical activity parameters.
- The number of SCD is rising on the highest and lowest **daily** levels of GMA. The relatively rare GMA storms concentrate most of SCD at days of lowest GMA.
- Days with SCD are accompanied by higher CRA (neutron activity on the Earth's surface) and is additionally increased at days with multiple SCD. These results are in agreement with observations in some other parts of the world [12, 13, 19].
- **Monthly** number of SCD was related to CRA and inversely related to SA and GMA.
- Gender differences in SCD links with GMA were found: men were more sensitive and apparently affected more.
- Cosmic Ray Activity could be considered as one of the regulating factors in human homeostasis [7, 12, 17, 18].

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REFERENCES

- [1] "Space Weather", P.Song, H. J.Singer, G. L.Siscoe (Eds.), American Geophysical Union's Geophysical Monograph Series, Vol.125, 2001.
- [2] F.Jansen, R.Pirjola, R.Favre, "Space Weather Hazard to the Earth?", Swiss Re Publishing, Zurich, 2000, 40 pages.
- [3] "Space Storms and Space Weather Hazards", I. A. Daglis (ed.), NATO Science Series, II. Mathematics, Physics and Chemistry, Kluwer Academic Publishers, 2001, Vol.38, 492 pages.
- [4] T.K.Breus, et al., "The Chronostructure of Heart Biorhythms under Effects of External Environmental Factors", Moscow, "Poligraf Servis", Press, 2002, 232 pages. (in Russian)
- [5] T.K.Breus, S.I.Rapoport, "Magnetic Storms: Medical-Biological and Geophysical Aspects", Moscow, "Sovetskii sport" Press, 2003, 192 pages. (in Russian)
- [6] B.M.Vladimirkii, et al, "Space Weather and Our Life", Fryazino, "Vek 2" Press, 2004, 224 pages. (in Russian)
- [7] E.Stoupel, "Cardiac Arrhythmia and Geomagnetic Activity", Indian Pacing and Electrophysiology Journal (ISSN 0972-6292), Vol.6(1), 2006, pp. 49-53.
- [8] S.Priori, D.P.Zipes, "Sudden Cardiac Death: A Handbook for Clinical Practice", Blackwell Publishing, 2005.
- [9] R.J.Myerburg, A.Castellanos, "Cardiac Arrest and Sudden Cardiac Death", E. Braunwald (ed.), Heart Disease. 5-th edition, Philadelphia, W.B. Saunders Company, 1997, pp. 742-779.
- [10] D.P.Zipes, H.J.J.Wellens, "Sudden Cardiac Death", Circulation, Vol.98, 1998, pp. 2334-2351.
- [11] "The AHA Clinical Cardiac Consult", J.S. Alpert (ed.), Lippincott Williams & Wilkins, 2001, p. 311.
- [12] E.Stoupel, et al., "Three Kinds of Cosmophysical Activity: Links to Temporal Distribution of Deaths and Occurrence of Acute Myocardial Infarction", Med. Sci. Monit., Vol. 10(2), 2004, pp. CR80-84.
- [13] E.Stoupel, et al., "Distribution of Monthly Deaths, Solar (SA) and Geomagnetic (GMA) Activity: Their Interrelationship in the Last Decade of the Second Millennium: the Lithuanian Study 1990-1999", Biomed. Pharmacother. Suppl.2, 2002, pp. 301-308.
- [14] E.Stoupel, "Sudden Cardiac Deaths and Ventricular Extrasystoles on Days with Four Levels of Geomagnetic Activity", J. Basic Clin. Physiol. Pharmacology, Vol. 4, 1993, pp.357-366.
- [15] E.Stoupel, "The Effect of Geomagnetic Activity on Cardiovascular Parameters", Editorial, Biomed. Pharmacother, Suppl.2, 2002, pp. 247-256.
- [16] E.Stoupel, et al., "Sudden Cardiac Death and Geomagnetic Activity: Links to Age, Gender and Agony Time", J. Basic Clin. Physiol. Pharmacology, Vol. 13(1), 2002, pp. 11-21.
- [17] E.Stoupel, et al., "Cosmic Rays Activity and Monthly Number of Deaths", J. Basic Clin. Physiol. Pharmacology, Vol. 13(1), 2002, pp. 23-32.
- [18] E.Stoupel, et al., "Neutrons and Sudden Cardiac Death (SCD) codes 121-125 ICD 10", J. Basic Clin. Physiol. Pharmacology, Vol. 17(1), 2006, pp. 45-54.
- [19] E.Stoupel, et al., "Are Neutrons Involved in the Pathogenesis of Life-Threatening Cardiac Arrhythmias?", J. Basic Clin. Physiol. Pharmacology, Vol. 17(1), 2006, pp. 55-62.