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A study of the possible relation of the cardiac arrhythmias occurrence to the polarity reversal of the solar magnetic field

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Abstract

The biological human system is probably affected by the solar and geomagnetic disturbances as well as the cosmic ray variations. In this work, the relation between the solar activity and cosmic ray variations and the cardiac arrhythmias over the time period 1997–2009 covering the solar cycle 23, is studied. The used medical data set refers to 4741 patients with cardiac arrhythmias and 2548 of whom were diagnosed with atrial fibrillation, obtained from the 2nd Cardiological Clinic of the General Hospital of Nicaea, Piraeus, in Greece. The smoothing method on a 365-day basis and the Pearson *r*-coefficient were used in order to compare these records with the number of sunspots, flares, solar proton events, coronal mass ejections and cosmic ray intensity. Applying a moving correlation function to ±1500 days, it is suggested that a change of the correlation sign between the medical data and each one of the above parameters occurs during a time interval of about 2–3 years. This interval corresponds to the time span of the polarity reversal of the solar magnetic field of this solar cycle, which always takes place around the solar cycle maximum. After then a correlation analysis was carried out corresponding to the rise (1997–2001) and the decay (2002–2009) phases of the solar cycle 23. It is noticeable that the polarity reversal of the solar magnetic field coincides with the period where the sign of the correlation between the incidence of arrhythmias and the occurrence number of the solar eruptive events and the cosmic ray intensity, changes sign. The results are comparable with those obtained from the previous solar cycle 22 based on medical data from another country.

Keywords: Cosmic ray intensity; Solar magnetic field; Cardiac arrhythmias; Atrial fibrillation

1. Introduction

As it is known, Space Weather refers to the environmental conditions in Earth's magnetosphere, ionosphere and thermosphere due to the Sun and the solar wind that can influence the functioning and reliability of space borne and ground-based systems and services or endangers property or human health (ESA, 2014). Space weather is caused by solar eruptive events such as solar flares and coronal mass ejections (CMEs) which in turn produce radiations, energetic particles and waves propagating into the interplanetary space and they affect the Earth's magnetosphere and the terrestrial environment. The helio-geomagnetic dis-

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turbances seem to affect, directly and indirectly, the human physiology as well as the human health (Palmer et al., 2006). Recent studies indicate a significant association between space weather parameters and the human physiology and health (Stoupel, 1999; Cornèlissen et al., 2002; Palmer et al., 2006; Stoupel et al., 2007a,b; Azcárate et al., 2012).

Various researchers have studied the impact of helio-geomagnetic activity on cardiovascular diseases (e.g. Stoupel and Shimshoni, 1991; Dorman et al., 2001; Oinuma et al., 2002; Dimitrova, 2008). Palmer et al. (2006) reported that 75% of geomagnetic storms are followed by an increase of 50% of hospital neurological and cardiological cases. Also, a good correlation between helio-geomagnetic activity and heart attacks has been indicated by Breus et al. (1989). Moreover, variations in hard cosmic ray flux constitute a prognostic indicator of changes in the number of cardiovascular cases (Styra et al., 2005). It is noticeable that the number of deaths due to heart attacks was increased in Minnesota by 5% during the maximum phase of the solar cycle, studying a 29-year period, while it was decreased in the solar minima (Cornèlissen et al., 2002).

Furthermore, Stoupel et al. (2005) noted a relationship between the death rate, especially due to acute myocardial infractions and space weather's parameters. It was also suggested that the monthly rates of them, in the time periods 1983–1999 and 2003–2005, are correlated with the cosmic ray activity and anti-correlated with the solar sunspot activity (Stoupel et al., 2007a,b). Recently, an increase of the incidents occurrence with Acute Coronary Syndromes was noticed during the recovery phase of some intense geomagnetic storms (Katsavrias et al., 2013).

Papailiou et al. (2011) using data from a number of 4011 aviators, showed a significant correlation between heart rate variations and high levels of geomagnetic activity as well as cosmic ray intensity decreases. Moreover, changes in human physiological parameters such as arterial systolic and diastolic pressure and heart rate during geomagnetic and cosmic ray intensity activities have been reported (Dimitrova, 2008; Papailiou et al., 2012).

It is known that cardiac arrhythmia (ARRY) is any change from the normal sequence of the electrical impulses of the heart (AHA, 2014). It is any disorder of the heart beat and usually it is expressed as a bradycardia or a tachycardia (Kremastinos, 2005). As a result of this disorder, heart does not work properly and does not pump the blood effectively. On account of this heart malfunction, damage may be incurred in brain, lungs and other organs (AHA, 2014). Atrial fibrillation (AF) is the most common arrhythmia in clinical practice (Zimetbaum and Falk, 2013). It is affecting an estimated population of 33 million worldwide, with an associated prevalence of approximately 1% (Chugh et al., 2013). Furthermore, 2.3 million Americans and 4.5 million people in the European Union are estimated to have AF, which is responsible for one-third of cardiac hospitalizations annually (Baez-Escudero and Valderrábano, 2014). Although AF is frequently asymptomatic, it is also a strong factor for increased stroke risk (Chugh et al., 2013; Ferguson et al., 2014) and has an associated 2-fold increase in mortality (Chugh et al., 2013).

Several studies have investigated the relation between the heart rhythm disturbances and the helio-geomagnetic activity (Stoupel and Shimshoni, 1991; Gigolashvili et al., 2010; Papailiou et al., 2011). Stoupel et al. (1994), in a period of 1185 consecutive days with low geomagnetic activity from January 1990 to March 1993, noticed that patients with paroxysmal atrial fibrillation presented a greater number of electrical heart instability events. Moreover, in such periods with low geomagnetic activity the number of ventricular extra systoles and supraventricular extra systoles, both of which are types of cardiac arrhythmias, increased (Stoupel and Shimshoni, 1991). Gigolashvili et al. (2010) showed the existence of a periodicity of 27 days in cardiac arrhythmias patients' number. In the same work a possible relation between the sector structure and the polarity sign of the interplanetary magnetic field during a Bartel rotation and the occurrence of the incidences with arrhythmia and especially those with multiple supraventricular paroxysmal tachycardia and ventricular extra systolic arrhythmias, is presented. Recently, Giannaropoulou et al. (2014) extended this work and focused on the possible relationship between the polarity reversal of the solar magnetic field that occurs 2–3 years around the solar maximum and the above occurrence number of referred types of arrhythmias, such as supraventricular extrasystols (S), supraventricular paroxysmal tachycardia (Ps), ventricular single extrasystols (V1) and ventricular multiple extrasystols (Vm). This work refers to a group of 1902 patients from Tbilisi, Georgia, covering the time period 1983–1992 (solar cycle 22). It was concluded that the polarity reversal of the solar magnetic field was connected with the sign and the value of the relation of the patients' number with the above types of arrhythmias and the solar, cosmic ray and geomagnetic parameters. Moreover, from that study it was resulted that the patients' number with types V1 and Vm of cardiac arrhythmias seems to be more sensitive to the changes of polarity sign of the solar magnetic field.

In this article the possible relation of the number of sunspots Rz, solar flares and CMEs as well as the cosmic ray intensity (CRI) on the occurrence number of patients with ARRY and especially on those with AF, is examined. Our analysis has been applied on medical data obtained from the General Hospital of Nicaea, Piraeus, Greece, for the time period 1997–2009, covering the period of the solar cycle 23. The study is focused on the possible connection between the polarity reversal of the solar magnetic field and the correlation sign between the medical data and the solar and CRI parameters, during solar cycle 23, searching for a corresponding relation similar to that already been noted during solar cycle 22.

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