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The effect of solar–geomagnetic activity during hospital admission on coronary events within 1 year in patients with acute coronary syndromes

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Abstract

Some evidence indicates the deterioration of the cardiovascular system during space storms. It is plausible that the space weather conditions during and after hospital admission may affect the risk of coronary events in patients with acute coronary syndromes (ACS). We analyzed the data of 1400 ACS patients who were admitted to the Hospital Lithuanian University of Health Sciences, and who survived for more than 4 days. We evaluated the associations between geomagnetic storms (GS), solar proton events (SPE), and solar flares (SF) that occurred 0–3 days before and after hospital admission and the risk of cardiovascular death (CAD), non-fatal ACS, and coronary artery bypass grafting (CABG) during a period of 1 year; the evaluation was based on the multivariate logistic model, controlling for clinical data. After adjustment for clinical variables, GS occurring in conjunction with SF 1 day before admission increased the risk of CAD by over 2.5 times. GS 2 days after SPE occurred 1 day after admission increased the risk of CAD and CABG by over 2.8 times. The risk of CABG increased by over 2 times in patients admitted during the day of GS and 1 day after SPE. The risk of ACS was by over 1.63 times higher for patients admitted 1 day before or after solar flares.

These findings suggest that the space weather conditions before and after hospital admission affect the risk of major adverse cardiovascular events during the period of 1 year.

Keywords: Geomagnetic activity; Solar proton events; Solar flares; Acute coronary syndromes; Coronary events

1. Introduction

A number of studies show that space weather conditions affect the cardiovascular system. Geomagnetic storms, Forbush decreases, storms sudden commencements, sharp increase in the negative Bz component of the interplanetary magnetic field, micropulsations (Pc1), and solar proton events increased the risk of myocardial infarction (Villoresi et al., 1998; Kuleshova et al., 2001; Cornelissen et al., 2002; Kleimenova et al., 2007; Dorman et al., 2008; Vencloviene et al., 2013). There is evidence indicating that geomagnetic storms are associated with decreased heart rate variability (Watanabe et al., 2001; Cornelissen et al., 2002); elevated blood pressure (Ghione et al., 1998; Dimitrova et al., 2004), blood coagulation and platelet aggregation (Pikin et al., 1998), increased blood viscosity, and decelerated blood flow (Oraevskii et al., 1998; Gurfinkel et al., 1995), reduced arterial baroreflex sensitivity and microcirculation (Gmitrov, 2005). The geomagnetic storms sharply disturbs

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the rhythm of the external synchronizer of biological rhythms (Oraevskii et al., 1998; Breus et al., 1998) and is therefore accompanied by an adaptation stress reaction of the organism (Breus et al., 2012).

Ischemic heart disease remains the most common cause of death worldwide (Murray and Lopez, 1997). Acute coronary syndromes (ACS) are an especially significant health problem, resulting in an increased risk of recurrent myocardial infarction and lethal outcome (Widimsky et al., 2010). The prognosis for patients with acute coronary syndromes generally depends on the occurrence and the extent of myocardial damage. However, research has shown that air pollution (Mustafic et al., 2012), meteorological conditions (Danet et al., 1999), space and geomagnetic storms, and other environmental factors increase the risk of myocardial infarction. Naturally, a question arises of whether further prognosis of patients with a history of ACS depends on the characteristics of the physical environment at the onset and during the first days of hospitalization. The effect of geomagnetic disturbances was stronger for patients with an impaired cardiovascular system (Zenchenko et al., 2009). It is plausible that the heliophysical conditions during and after admission may affect the risk of adverse cardiovascular events for ACS patients during one-year period.

The aim of this study was to assess the risk of coronary events (cardiovascular death, non-fatal ACS – myocardial infarction (MI) or unstable angina, and coronary artery bypass grafting (CABG)) during 1 year after hospital admission for ACS patients with relation to the patients' condition and geomagnetic activity, solar proton events, and solar flares during and after hospital admission.

2. Data and methods

The study was conducted in Kaunas city (geomagnetic latitude 52.38 N) during 2005. Data on hospital admissions for acute coronary syndromes were obtained from the Clinic of Cardiology, Hospital of Lithuanian University of Health Sciences (formerly, Kaunas University of Medicine). Ca. 80% of patients with acute coronary syndromes (ACS) from Kaunas city and Kaunas County are admitted to the University Hospital Center of Cardiology where coronary angiography and percutaneous transluminal coronary angioplasty (PTCA) are available at the Department of Angiography, which operates round the clock. Ca. 20% of patients from this region are treated in other two hospitals of the Kaunas city because of contraindications to invasive procedures, severe concomitant diseases, or logistic issues. We used data on 1481 patients who were treated for acute myocardial infarction (code I21) or unstable angina (code I20.0), and survived after ACS for more than 4 days. Of these, 11 (0.7%) patients died from other causes, 70 (4.7%) patients had missing data endpoints, and for 1400 patients the data about the endpoints (death, non-fatal ACS, or myocardial revascularization) were available for the period of 1 year. Myocardial infarction was diagnosed according to the WHO guidelines: angina pain and equivalent, ischemic signs of ECG (Q wave, ST and T changes), and an increased troponin I level (>0.5 μg/L). Coronary artery (CA) angiography was performed by applying the Judkins technique. Severe stenosis of 1, 2, or 3 vessels was defined as a narrowing of the coronary artery >70%. Patients with signs of acute myocardial infarction and heart failure were ranked according to the Killip classification.

Data on the north solar flares, solar proton events (SPE), and geomagnetic activity (GMA) were used as space weather data. Daily Ap indices were used as a measure of the level of geomagnetic activity. As geomagnetic storms (GS) we selected all ($Ap \geqslant 30$) geomagnetic storms according to NOAA classification. In the analysis, the daily GMA was classified as quiet ($Ap < 8$), unsettled–active ($8 \leqslant Ap < 30$), stormy ($Ap \geqslant 30$) or active–stormy ($Ap \geqslant 16$). The daily north flare index expressed in binary values - "no flare" (daily north flare index = 0; and "yes flare" (daily north flare index > 0) – was used as the measure of the level of north solar flares. Ap and flare indexes were downloaded from the joint USA/European Solar and Heliospheric Observatory (web site: ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/).

The SPE was defined as integral 5-minute averages of proton energies >10 MeV exceeding 10 proton/(cm^2-s-sr). Daily average of proton >10 MeV flux, which was downloaded from the National Geophysical Data Centers OMNIWeb data base (http://omniweb.gsfc.nasa.gov/) was used as a measure of the level of SPE. According to the specifications of our study SPE was considered to have occurred if the daily average of proton >10 MeV flux was over 10.

2.1. Statistical analysis

To evaluate the risk of coronary events (cardiovascular death, non-fatal ACS, and CABG) during the one-year period, we used the multivariate logistic regression. In the logistic regression model created for cardiovascular death and non-fatal ACS, we used the data of patients with these endpoints and patients without other endpoints. To evaluate the risk for CABG during the one-year period, we used data of patients who had CA stenosis over 50% and no CABG during hospitalization. At first, by using the χ^2 test, we identified the patients' baseline characteristics that were significantly associated with the outcomes. We used patients' age, sex, medical history (MI, recurrent ischemia, pulmonary disease, stroke, arterial hypertension, diabetes, and the number of the component of the metabolic syndrome), diagnosis, clinical characteristics on admission (heart rate, paroxysmal atrial fibrillation, Killip class, and troponin level), pulmonary hypertension, the number of CA with stenosis, and treatment during hospitalization. Subsequently, we create a multivariate logistic model for each outcome by the backward stepwise method, using the significant variables. The effect of space weather vari-