

Timing of life-threatening arrhythmias detected by implantable cardioverter-defibrillators in relation to changes in cosmophysical factors

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Abstract

Background: *Studies have linked the natural history of many pathologies with environmental physical activity. This study investigated the relationship between the occurrence of ventricular tachycardia/fibrillation (VT/VF) recorded by implantable cardioverter defibrillators (ICD) and geomagnetic and cosmic ray (neutron) activity.*

Methods: *The study group included 85 patients (73 men) with cardiomyopathy (80% ischemic) who underwent ICD placement in the years 1995–2006; 74% had a left ventricular ejection fraction of < 30%. Data on the days on which VT/VF occurred (total number of days: 284) and the days on which the patients were treated (total number of treatments: 580) were collected from the ICD records. The findings were analyzed against levels of geomagnetic activity (GMA) (I°–IV°) and cosmic ray activity (CRA), derived from international observatories, on the same days and throughout the study period.*

Results: *On days of VT/VF, daily values of GMA level averaged 1.5 ± 0.7 , consistent with level I° (quiet). The ratios of daily VT/VF episodes and treatment to GMA level for the whole study period were as follows: 1.2 level I; 0.9 level II; 0.69 level III; 0.78 level IV ($r = -0.974$; $p = 0.02$). Mean CRA on days of VT/VF was 9246.8 ± 299.0 imp/min, and for all 4383 days studied, 8805.33 ± 411.4 imp/min ($p < 0.0001$).*

Conclusions: *In patients with predominantly ischemic cardiomyopathy and severe left ventricular dysfunction, VT/VF occurs more often on days of low GMA and high CRA. Further studies are needed to determine the underlying mechanism of the effect of neutron activity on cardiac electrical instability. (Cardiol J 2008; 15: 437–440)*

Key words: ventricular tachycardia, ventricular fibrillation, implantable cardioverter defibrillator, geomagnetic activity, cosmic ray (neutron) activity

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Introduction

Sudden cardiac death (SCD) remains a fundamental problem in cardiology [1]. In the individual patient, SCD tends to occur in close proximity to the occurrence of life-threatening cardiac arrhythmia; the most frequent triggers are ventricular tachycardia (VT) and ventricular fibrillation (VF) [1]. Studies have reported an apparent link between the risk of SCD and levels of certain environmental physical factors [2–5]. Given the current ability of clinicians, and thanks to recent technological advances that allow us to more precisely fix the time of arrhythmia preceding SCD, we sought to analyze the time of occurrence of VT and VF, as recorded by implantable cardioverter defibrillators (ICD), against concomitant daily geomagnetic activity (GMA) and cosmic ray activity (CRA) in order to further our understanding of the cosmobiology of SCD.

Methods

The study group included 85 patients, 73 men (85.9%) and 12 women, who underwent placement of an ICD between 1995 and 2006. All had ischemic (80%) or other forms of cardiomyopathy accompanied by life-threatening cardiac arrhythmia. Mean (\pm SD) patient age was 69.35 ± 11.37 years; for men, 70.15 ± 11.33 years (median 73, range 36–86) and for women, 64.77 ± 13.63 years (median 62, range 36–81). For patients without ischemic cardiomyopathy (ICM) the age was 52.55 ± 11.6 (median 51, range 36–71).

In 63 patients (74%), left ventricular ejection fraction was less than 30%. The mean observation time per patient from ICD implantation to last VT/VF event was 3.33 ± 2.27 years (median 3, range 1–12).

Among the patients with ICM, 61 (89.7%) suffered acute myocardial infarction (AMI), 10 (14.7%) multiple myocardial infarction, in the past; 34 (50.00%) patients previously underwent coronary artery bypass grafting (CABG), 4 repeatedly, and 5 also had valve replacement and 6 had surgery for cardiac aneurysm. All these events took place more than 10–15 years before the patients were treated by ICD. Twelve (14.2%) also suffered from chronic renal failure (CRF), part treated by hemodialysis. Nine patients had chronic or paroxysmal atrial fibrillation. Nine patients (10.5%) were treated by cardiac resynchronization therapy, biventricular pacing for congestive heart failure (CHF). Three additional patients had pacemakers for heart conduction problems. Concomitant factors like such as hyperlipidemia, arterial hypertension, diabetes mel-

Table 1. Geomagnetic activity gradation.

Category	"A" index range	Typical "K" values	Amplitude (nanotesla)
Quiet (I°)	$0 < A < 8$	Usually No. > 3	0–20
Unsettled (II°)	$8 < A < 16$	Usually No. > 3	21–40
Active (III°)	$16 < A < 30$	Few indices of 4	41–70
Minor storm (IV°)	$30 < A < 50$	Mostly 4 and 5	71–120
Major storm (IV°)	$50 < A < 100$	Some indices 6	121–200
Severe storm (IV°)	$100 < A$	Some indices 7	201– > 550

litus and smoking in the past were accompanied the natural history of most of these patients, as is often the case in ICM.

Nine (10.5%) patients had thyroid problems as a complication of long amiodaron (Procor) use. In addition, two patients were diagnosed with Procor lungs.

As well as this drug, patients were treated with statins for hyperlipidemia, antiplatelet drugs, angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blocker (ARB), aldosterone antagonists and by CHF, diuretics, carvedilol and less frequent by other beta-blockers for heart failure.

Among our patients, 7 (8.2%) underwent aborted SCD and 8 (9.4%) had repeated syncope.

For the present study, ICD data were collected for each patient for the entire observation period (4383 days) and for the days on which VT/VF was recorded by ICD and treated. GMA and CRA values on the same days, and throughout the study period, were derived from international observatories: United States Air Force National Geophysical and Space Weather Prediction Centers [6–8], Izmiran Institute of the Russian Academy of Sciences [9], and Oulu University Neutron Monitoring Station [10]. GMA was measured using Ap., Cp., Am indices, by level (Table 1), and CRA was calculated from measurements of neutron activity on the Earth's surface in impulses/minute.

Statistical analysis

Pearson correlation coefficients (r) and their probabilities and Student's t-test were used to analyze comparative data. P values of 95% and higher were considered significant, and values of 90–94% as strong trends toward statistical significance.

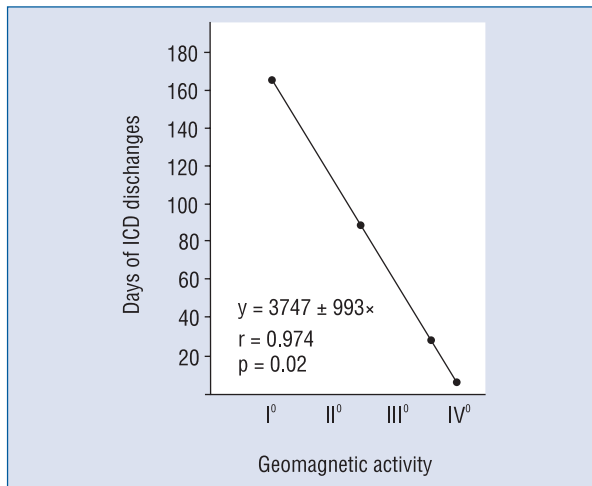


Figure 1. Geomagnetic activity level (I–IV) on days ($n = 284$) of implantable cardioverter-defibrillator (ICD) treatments of ventricular tachycardia/ventricular fibrillation.

Results

Episodes of VT/VF were recorded on a total of 284 days during the observation period, and a total of 580 treatments were administered by the defibrillators.

On days of VT/VF, the daily values of GMA level averaged 1.5 ± 0.7 , consistent with level I (quiet). Figure 1 presents the inverse correlation between levels of GMA and VT/VF occurrence ($r = -0.974$, $p = 0.02$). By contrast, as shown in Figure 2, for the whole observation period (4383 days) neutron activity was significantly higher on days of VT/VF ($p < 0.0001$). Indices of GMA for 1990–2006 were strongly and inversely correlated with CRA: $r = -0.55$, $p < 0.0001$; solar activity indices also showed a similar relationship with CRA: $r = -0.75$, $p < 0.0001$.

Discussion

Studies conducted in the last 15 years have demonstrated an apparent association of the occurrence of cardiac arrhythmias and SCD with changing levels of geomagnetic and cosmic ray (neutron) activity [2–5, 10, 11]. Using 24-hour Holter monitoring, we previously showed that more atrial and ventricular premature contractions occurred on days of lowest I° (quiet) GMA than on days of higher GMA [10]. Similar data were noted for ventricular tachycardia [12]. The findings for paroxysmal atrial fibrillation were confirmed in a separate study [13]. A recent study of ICD discharges in respon-

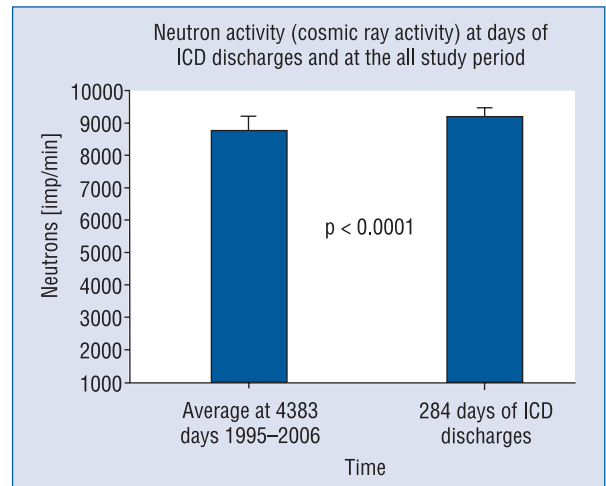


Figure 2. Cosmic ray activity (neutron activity) in imp/min on days of implantable cardioverter-defibrillator (ICD) treatments ($n = 284$) for ventricular tachycardia/ventricular fibrillation compared to the average during the whole observation period 1995–2006 (4383 days).

se to VF in patients meeting the criteria of the Multicenter Automatic Defibrillator Implantation Trial II (MADITT II) showed that ventricular extrasystoles were the basic trigger of VF [14].

Investigations of SCDs specifically revealed that SCDs occurring within 3 hours of life-threatening arrhythmia occurred more often on days of low GMA [2]. These findings were supported by additional studies conducted in different geographic areas wherein days of lowest GMA were found to be characterized by more SCDs within one hour of onset of symptoms in men aged more than 65 years and fewer deaths within 1–24 hours of symptoms in women aged more than 65 years [3]. The rate of occurrence of early SCDs (within one hour of symptoms) decreased as daily GMA levels increased [5]. Similar findings were noted for acute myocardial infarction [15].

The results of the present study confirm our early report of the relationship between ICD discharges and low GMA [16]. In response to critiques that our initial findings may have been coincidental [17], we included a much larger sample over a longer term and measured both GMA and CRA simultaneously. We noted higher CRA on days of VT/VF, in agreement with other studies reporting greater activity on days of ICD discharges [18] and on days of SCDs related to AMI [15, 19]. In addition, a post-mortem study of 780 patients found an association between CRA and death due to myocardial rupture, repeated AMI and coronary thrombosis with SCD preceding AMI [4].

We presume that higher CRA, which occurs at times of lower GMA and lower solar activity [20], contributes to electrical heart instability, especially in patients with damaged heart muscles as a consequence of repeated AMI or ischemic cardiomyopathy, as in our series. We presume that neutrons bind to the H⁺ that is readily available in tissue lipids, forming protons that disturb normal tissue functioning. This activity is highly damaging to the nuclei of cells already damaged by ischemia or infarction, as shown in radiotherapy studies [21]. The changes are accompanied by electrical heart instability, conduction asynchrony, extrasystole, VT, and VF [2–5, 14, 16, 18, 19].

These findings should form the basis of further studies to determine if artificial magnetic fields can shield patients with ICDs from life-threatening arrhythmias (with consideration of its possibly damaging effect on the device and potential effects on coagulation and inflammation markers) [11, 22]. It should be noted that treatment by magnetic fields is already being used for patients with severe depression [23, 24].

Limitations of the study

The majority of patients in the present study were male and had ischemic cardiomyopathy. Studies have shown that ICD function differs in women and in patients with other types of cardiomyopathy/heart muscle pathologies [25], so inclusion of a more varied range of patients would provide additional information.

Conclusions

Implantable cardioverter defibrillator recordings and treatment of episodes of VT/VF appear to be inversely correlated with the daily level of GMA and directly correlated with CRA (as measured by neutron fluctuations). Studies are needed to determine the underlying mechanism of the possible arrhythmogenic effect of physical environmental changes.

Acknowledgements

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