

The World Trade Center Attack: Increased Frequency of Defibrillator Shocks for Ventricular Arrhythmias in Patients Living Remotely From New York City

Omer L. Shedd, MD,* Samuel F. Sears, JR, PhD,† Jane L. Harvill, PhD,‡ Aysha Arshad, MBBS,§ Jamie B. Conti, MD, FACC,† Jonathan S. Steinberg, MD, FACC,§ Anne B. Curtis, MD, FACC† Gainesville, Florida; Starkville, Mississippi; and New York, New York

OBJECTIVES	The goal of this study was to determine whether the World Trade Center (WTC) attack on September 11, 2001, had an effect on the occurrence of ventricular arrhythmias among patients with implantable cardioverter-defibrillators (ICDs) living in Florida.
BACKGROUND	Increased frequencies of ICD therapies for ventricular arrhythmias were reported among patients in New York City after the attack on the WTC. Whether this effect also occurred in patients living geographically distant from New York is unknown.
METHODS	This was an observational study consisting of 132 ICD patients who presented to the University of Florida and the Veterans Affairs Medical Center in Gainesville, Florida, for routine ICD follow-up around the time of the WTC attack. The occurrence of ventricular tachyarrhythmias triggering ICD therapy in the 30 days before and after September 11 constituted the primary end point.
RESULTS	In the 30 days following the WTC attack, a total of 14 patients (11%) had ventricular tachyarrhythmias, compared with 5 (3.8%) in the preceding 30 days ($p = 0.0389$, 95% confidence interval [CI] 0.4 to 13.3). This represents a 2.8-fold risk increase. Patients with ventricular arrhythmias both before and after September 11 demonstrated a rate increase of 2.38 events per patient ($p = 0.0231$, 95% CI 1.03 to 13.97).
CONCLUSIONS	The frequency of ventricular arrhythmias requiring ICD treatment increased by 68% among patients in Florida around the WTC attack. These findings suggest that stress-related arrhythmogenesis due to the WTC tragedy was not restricted to the geographic location of the attack. A major national tragedy may cause widespread increased risk of potentially life-threatening ventricular arrhythmias. (J Am Coll Cardiol 2004;44:1265-7) © 2004 by the American College of Cardiology Foundation

Cardiovascular and psychological reactions in persons experiencing sudden and severe life stress have been directly linked in previous research examining natural disasters and missile attacks (1-3). Recent research examining arrhythmogenic events in implantable cardioverter-defibrillator (ICD) patients has implicated both physical and mental stress as possible triggers for ventricular tachycardia (VT) or ventricular fibrillation (VF) (4,5). Major life events likely trigger negative emotions that have been deemed as possibly "the cause, rather than a consequence, of arrhythmia events" (6).

The events of September 11, 2001, exposed the U.S. population via media coverage to the sudden and tragic death of a large number of persons. The potential exposure via news media and the possible threat of broadly targeted terrorism elevated rates of post-traumatic stress from 17% two months after the attacks and 5.8% six months afterward (7). Prospective detailed research using a New York City sample of patients with ICDs indicated there was a 2.3-fold greater risk of ventricular tachyarrhythmias during the month following September 11 than during the preceding

month (8). The purpose of this study was to compare the incidence of ventricular tachyarrhythmias before and after September 11 in a sample of Florida ICD patients geographically removed from the tragedy.

METHODS

This was an observational study of 132 consecutive ICD clinic patients who presented to the University of Florida and the Veterans Affairs Medical Center (Gainesville, Florida), for routine ICD follow-up around the time of the World Trade Center (WTC) attack. Clinic logs at each institution were reviewed, and patients who presented to clinic after October 11, 2001, were identified. No known selection bias was influential in this study. The study period for the primary end point was defined as the 60-day period extending from 30 days before to 30 days after September 11. However, the observational interval to obtain all demographic data and electrogram data began May 11, 2001, and extended to February 11, 2002, for each patient. Demographics and clinical data for each patient were obtained from the clinic charts. Comprehensive ICD interrogation reports for each patient over the eight-month period were identified and reviewed by an electrophysiologist. Any ventricular tachyarrhythmia triggering therapy of either antitachycardia pacing (ATP) or shock was recorded and verified by careful analysis of the electrograms for each

From the *Division of Cardiovascular Medicine and Malcolm Randall Veteran Affairs Medical Center and the †Department of Clinical and Health Psychology, University of Florida, Gainesville, Florida; ‡Department of Mathematics and Statistics, Mississippi State University, Starkville, Mississippi; and §St. Luke's-Roosevelt Hospital, New York, New York.

Manuscript received December 25, 2003; revised manuscript received April 13, 2004, accepted April 27, 2004.

Abbreviations and Acronyms

- ATP = antitachycardia pacing
- CI = confidence interval
- ICD = implantable cardioverter-defibrillator
- VF = ventricular fibrillation
- VT = ventricular tachycardia
- WTC = World Trade Center

event, including dates, times, and tachyarrhythmia cycle length. Therapies for supraventricular tachyarrhythmias were excluded from the study. The University of Florida and the Malcolm Randall Veterans Affairs Medical Center Institutional Review Boards approved the study protocol.

Study and statistical analysis. Data are presented as percentages or means \pm SD. The occurrence of ventricular tachyarrhythmias (VF or VT) that triggered ICD therapy the 30 days before and after September 11 constituted the primary end point. As a secondary end point, any hospitalizations during the same study period were also recorded and analyzed. Both of these end points were compared using McNemar's test. Comparisons of ejection fraction, medications, and type of underlying heart disease between patients with and without ventricular arrhythmias during the 60-day study period were made with chi-square testing. No known selection bias was influential in this study.

RESULTS

Patient characteristics. The clinical characteristics of the study population are shown in Table 1. The population was predominantly elderly male Caucasians with coronary artery disease and impaired left ventricular systolic function. One death recorded during the study period was unrelated to cardiac disease. The majority of patients were taking beta-blockers as well as angiotensin-converting enzyme inhibitors. The most common indication for ICD implantation was sustained ventricular tachyarrhythmias. A significant portion of the patients had prophylactic ICD placements based on Multicenter Automatic Defibrillator Implantation Trial (MADIT I) criteria (9).

When comparing patients with ventricular arrhythmias during the study period to patients without arrhythmias, we found no statistically significant difference in gender, age, or left ventricular ejection fraction. Additionally, there were no statistically significant differences between medications; type of heart disease; or the presence of hypertension, diabetes, or hyperlipidemia (Table 2).

Incidence of ventricular tachyarrhythmias. During the 60-day study period, a total of 15 patients experienced ventricular arrhythmias requiring therapy. In the 30 days following the WTC attack, a total of 14 patients (11%) had ventricular tachyarrhythmias, compared with only 5 patients (3.8%) in the preceding 30 days ($p = 0.0389$, 95% confidence interval [CI] 0.4 to 13.3). This represents a 2.8-fold increase in risk. Four patients who had ventricular tachyar-

Table 1. Clinical Characteristics of Study Patients

Age (mean), yrs	62.8 \pm 3.2
Gender, %	
Male	85
Female	15
Race, %	
White	87
Black	6
Other	7
Hypercholesterolemia, %	59
Hypertension, %	76
Diabetes, %	20
Smoking history, %	41
Average time since ICD implant, yrs	3.1 \pm 0.4
LV ejection fraction (mean), %	33.9 \pm 2.6
LV ejection fraction range, %	10-90
Underlying heart disease, %	
Ischemic cardiomyopathy	60
Non-ischemic cardiomyopathy	14
Hypertrophic cardiomyopathy	2
Other	14
Medications, %	
Beta-blockers	66
ACE inhibitors	60
Antiarrhythmic drugs	41
Statins	56
ICD indication, %	
VT	52
VF	21
MADIT I	21
Other	6

ACE = angiotensin-converting enzyme; ICD = implantable cardioverter-defibrillator; LV = left ventricular; MADIT = Multicenter Automatic Defibrillator Implantation Trial; VF = ventricular fibrillation; VT = ventricular tachycardia.

rhythmias during the 30 days before September 11 had an increase from 1 to 2.38 events per patient during the 30 days after September 11 ($p = 0.0231$, 95% CI 1.03 to 13.97).

The majority of arrhythmias detected and treated were VTs (81%) with a mean cycle length of 368 ms. The mean cycle length of ventricular arrhythmias detected and treated in the VF zone (19%) was 294 ms. The most common modality of treatment for ventricular arrhythmias was anti-tachycardia pacing (57% ATP vs. 43% shock).

Rate of hospitalization. During the study period an increase in hospitalizations was observed (two hospitalizations before September 11 and five afterward); however, the increase was not statistically different.

DISCUSSION

The major finding of this study is that the frequency of ventricular arrhythmias requiring ICD treatment increased 2.8-fold among patients living in Florida around the time of the WTC attack. Moreover, patients with ventricular arrhythmias in the 30 days before and after September 11 experienced at least a doubling of the rate of arrhythmias during the 30 days after the attack. This is the first study to establish the effects of stressful events or attacks of terrorism on persons geographically distant from the event. Their main exposure to the actual life threat was via multi-media communications. The increased rates of arrhythmias in this

Table 2. Comparison of Independent Variables in Patients With Ventricular Arrhythmias Who Received ICD Therapy and Those Without Ventricular Arrhythmias

	Ventricular Arrhythmia (n = 15)	No Ventricular Arrhythmia (n = 118)	p Value
LV ejection fraction (mean), %	33.4 ± 3.3	34.4 ± 1.4	0.993
Underlying heart disease, %			~0.9*
Ischemic heart disease	66.7 (10)	71.2 (84)	
Non-ischemic cardiomyopathy	20.0 (3)	13.6 (16)	
Hypertrophic cardiomyopathy	0 (0)	2.5 (3)	
Other	13.3 (2)	12.7 (15)	
Medications, %			
Beta-blockers	80.0 (12)	64.4 (76)	0.856
ACE inhibitors	66.7 (10)	59.3 (70)	0.678
Antiarrhythmic drugs	46.7 (7)	39.8 (47)	0.919
Statins	33 (5)	58.5 (69)	0.567

Chi-square test used for independence. *The specific p value cannot be accurately calculated given the small sample size of some variables.

Abbreviations as in Table 1.

Florida ICD patient sample were consistent with previously reported clinical data from a New York City ICD patient sample (8).

These data cannot be extrapolated to the general population in the U.S., but they raise the question of whether the effects of September 11 had widespread adverse arrhythmogenic effects across the country. If true, the morbidity and mortality from such events may be significantly underestimated.

Because these data extend the hypothesized relationship between stressful events and increased arrhythmias among patients with arrhythmogenic heart disease, a primary prevention strategy is needed to treat this population. First, identifying which types of cardiac patients are most at risk for event-related arrhythmias will allow for targeted psychological intervention. Second, a public health strategy should coordinate a planned response to cardiac arrhythmias and involve emergency care, media, and personal and familial strategies to ensure the safety and efficacy of care for at-risk persons. Physicians could discuss strategies to treat patients susceptible to high anxiety states and possible arrhythmic events with either a long-term strategy or short-term crisis-directed therapy using anxiolytic therapy and psychiatric/psychological care.

Study limitations. We did not evaluate whether subjects had significant relationships with persons in New York, which might theoretically have predisposed them to increased levels of anxiety over the general population. Additionally, we did not collect data identifying whether subjects had a previously diagnosed anxiety. No analysis was made in the years before or after September 11; therefore, we cannot exclude similar increases occurring at the same time of year. Finally, the number of patients evaluated in this study was small; however, the effect remained significant regardless of the limited size.

Conclusions. The frequency of ventricular arrhythmias requiring ICD treatment increased 2.8-fold among patients

living in Florida around the time of the WTC attack. These findings suggest that stress-related arrhythmogenesis due to the attack was not restricted to the geographic location of the event. A major national tragedy may cause a widespread increase risk of potentially life-threatening ventricular arrhythmias. Treatment plans should be developed to identify patients at risk for stress-related arrhythmogenesis and reduce the levels of anxiety around times of crisis.

Reprint requests and correspondence: Dr. Omer L. Shedd, University of Florida, 1600 S.W. Archer Road, Box 100277, Gainesville, Florida 32610. E-mail: omergosh@ufl.edu.

REFERENCES

- Rozanski A, Blumenthal JA, Kaplan J. Impact of psychological factors on the pathogenesis of cardiovascular disease and implications for therapy. *Circulation* 1999;99:2192-217.
- Leor J, Poole WK, Kloner RA. Sudden cardiac death triggered by an earthquake. *N Engl J Med* 1996;334:413-9.
- Meisel SR, Kutz I, Dayan KI, et al. Effect of Iraqi missile war on incidence of acute myocardial infarction and sudden death in Israeli civilians. *Lancet* 1991;338:660-1.
- Fries R, Konig J, Schafers HJ, Bohm M. Triggering effect of physical and mental stress on spontaneous ventricular tachyarrhythmias in patients with implantable cardioverter-defibrillators. *Clin Cardiol* 2002;25:474-8.
- Lampert R, Joska T, Burg MM, Batsford WP, McPherson CA, Jain D. Emotional and physical precipitants of ventricular arrhythmia. *Circulation* 2002;106:1800-5.
- Dunbar SB, Kimble LP, Jenkins LS, et al. Association of mood disturbance and arrhythmia events in patients after cardioverter defibrillator implantation. *Depress Anxiety* 1999;9:163-8.
- Silver RC, Holman EA, McIntosh DN, Poulin M, Gil-Rivas V. Nationwide longitudinal study of psychological responses to September 11. *JAMA* 2002;288:1235-44.
- Steinberg JS, Arshad A, Kowalski M, et al. Increased incidence of life-threatening ventricular arrhythmias in implantable defibrillator patients after the World Trade Center attack. *J Am Coll Cardiol* 2004;44:1261-4.
- Moss AJ, Hall WJ, Cannom DS, et al. Improved survival with an implanted defibrillator in patients with coronary disease at high risk for ventricular arrhythmia. Multicenter Automatic Defibrillator Implantation Trial Investigators. *N Engl J Med* 1996;335:1933-40.