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Ventricular Ectopy: Impact of Self-reported Stress following Myocardial Infarction

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Abstract

Background—Although psychological stress has been implicated in the pathogenesis of ventricular arrhythmias, the relationship between self-reported stress and ventricular ectopy has not been evaluated under naturalistic conditions in acute post-MI patients, a group at elevated risk for arrhythmias.

Methods—Diary-reported stress was measured during 24-hour Holter monitoring in 80 patients (52 men, 28 women) approximately 12 weeks following MI. In addition, state and trait anxiety were measured using the Spielberger State and Trait anxiety inventory (STAI), administered at the beginning of the 24-hour holter monitoring session. The relationship between diary reported stress, anxiety, and ventricular ectopy was evaluated.

Results—Mean diary-reported stress ($\beta = .29$, $p = .01$) was associated with total ventricular ectopy. State anxiety was also associated with 24-hour ectopy ($\beta = .24$, $p = .04$); however, trait anxiety was not significantly associated with ectopy. Temporal analyses of the relationship between stress and ectopy showed that diary-reported stress was associated with an increase in the number of VPBs occurring in the following hour ($B = 0.74$, $p < .0001$).

Conclusions—These findings extend existing evidence linking psychological factors to ventricular arrhythmias by demonstrating that psychological stress predicts increased arrhythmic activity during routine daily activities in post-MI patients.

Keywords

myocardial infarction; ventricular arrhythmia; stress

Approximately 85% of patients with coronary heart disease (CHD) experience ventricular premature beats (VPBs) (1). Although clinical risk factors such as left ventricular ejection fraction (LVEF) predict VPBs among individuals with CHD, psychological factors, such as psychological stress (2), anxiety (3,4) and depression (5,6) may also be associated with increased arrhythmias in this population. A growing body of evidence suggests that state-dependent psychological factors, such as mental stress and anxiety, may be associated with an

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increased risk of ventricular ectopy among individuals with CHD (7,8). Although previous research has demonstrated a relationship between psychological factors and VPBs in populations with compromised cardiac functioning, such as congestive heart failure (CHF) (8), this association has not yet been studied among cardiac patients with preserved LVEF.

Previous studies have shown that mental stress is associated with increased rates of VPBs among cardiac patients assessed under laboratory conditions (2). The relationship between psychological factors and VPBs may be particularly important following myocardial infarction (MI) given that post-MI patients are more susceptible to the arrhythmogenic effects of psychological distress due to a vulnerable myocardium (9,10). For example, psychological distress during hospitalization for MI has been shown to predict ventricular ectopy following discharge (11-13). These findings are limited, however, by the measurement of distress and ectopy at separate time points and by the potential impact of peri-hospitalization events and/or diagnoses on self-reported levels of distress.

The purpose of this study was to investigate the relationship between psychological stress and VPBs measured concurrently under naturalistic conditions following recovery from acute MI. In addition, the association between anxiety and VPBs was evaluated. In order to investigate these relationships, 80 post-MI patients completed psychosocial measures assessing anxiety and reported psychological stress in a diary concurrently with 24-hour holter monitoring. It was hypothesized that higher levels of anxiety and self-reported diary ratings of stress would be positively associated with ventricular ectopy during this 24-hour monitoring period.

Methods

Experimental Design

Acute post-MI patients were recruited during hospitalization at Duke University Medical Center. Patients in the current analysis represent a subset of a larger study sample recruited for an ongoing investigation of heart rate variability recovery following MI (the HARMONY study). In order to assess the relationship between stress and ventricular ectopy following autonomic recovery, the current study investigated the association between diary-reported stress and ventricular ectopy during a 24-hour period 12 weeks post-MI, when autonomic cardiac control is considered to have reached full recovery (14). The study was approved by the Duke University Medical Center Institutional Review Board and all patients gave written informed consent before participating in the research protocol.

Patient Sample

Myocardial infarction was defined by serial cardiac enzyme changes and either electrocardiograph (ECG) changes or cardiac symptoms. Acute post-MI patients were identified and screened for enrollment from January 2004 to February 2005. As shown in Figure 1, 889 acute post-MI patients were available for screening and approximately 84% did not qualify for the study. The most common reason for excluding patients was cardiac-related criteria (ejection fraction < 30%, pacemaker or irregular heart rhythm during the acute post-MI period, recent or planned coronary artery bypass grafting that could affect arrhythmias, MI secondary to a surgical procedure or recreational drug use), medical/psychiatric comorbidity (current or recent alcohol or drug abuse, significant barriers to mobility such as paraplegic or wheelchair/walker bound, intubation, metastatic cancer or end stage renal disease, psychosis, dementia), and logistical/language barriers (language barriers that prevented reliable communication, current incarceration, and inability to assess patients following discharge due to distance barriers). Patients who did not meet enrollment criteria or who refused to participate in the study did not differ significantly in age, race, or gender from the final sample.

Ambulatory ECG Monitoring

Patients underwent 24-hr holter monitoring using a Del Mar Reynolds Lifecard CF, 3-channel digital recorder (Del Mar Reynolds, Irvine, CA). Instrumentation took place in patients' homes prior to each 24-hour assessment. The ambulatory ECG recordings were analyzed for PVCs, couplets, triplets, bigeminy, trigeminy, salvo, and ventricular tachycardia. The total number of VPBs over this 24-hour period was determined by summing the number of VPBs from each of the above categories of ventricular arrhythmias.

Diary of Stressful Events

During the 24-hour ECG monitoring, patients rated the amount of stress they experienced during their daily activities in a pocket-sized diary. Patients were prompted by a beeper once every 30 minutes to rank the amount of stress they had experienced over the preceding five minutes. The beeper was set to alert patients once every 30-min during their waking hours. Stress was ranked on a 4-point intensity scale from 1 (*not at all*) to 4 (*very much*). Patients were asked to endorse any cardiac symptoms they experienced during the preceding half-hour in each diary entry (chest pain, palpitations, light-headedness, and shortness of breath). The present analysis used the mean diary stress score from the 24-hour assessment as the measure of psychological stress experienced during the day.

State and Trait Anxiety

Patients completed the *Spielberger State-Trait Anxiety Inventory* (15) as part of their psychosocial evaluation. The STAI has been used in medical and surgical patients and consists of 40 self-report items assessing the degree of anxiety experienced at the time of form completion (state anxiety) as well as the amount of time feeling anxious during everyday life (trait anxiety).

Data Analysis

General linear modeling equations (SAS Inc., Cary, North Carolina) were used to examine the association between diary-reported stress and total VPBs over the 24-hour assessment period and to determine whether this association was moderated by any clinically relevant cardiac variables. In addition, the temporal relationship between diary entries of stress and VPBs was examined using general estimating equations (GEE) with SAS PROC GENMOD (SAS Institute, Cary, NC). In these models, data are structured so that information on diary-reported stress, posture, and VPBs are available for every hour of monitoring for each person. The model specified the logarithm of the number of ectopic beats as the dependent variable and the diary variables as predictors. Two patients with incomplete data were excluded from the final analysis: one who did not complete a diary and one with less than 20 hours of holter monitoring data. LVEF, age, gender, and coronary artery disease (CAD) severity were selected *a priori* as covariates in the model with diary-reported stress as the independent predictor of 24-hour VPBs, as these have been previously identified as independent predictors of ventricular arrhythmias. CAD severity was indexed by the number of coronary vessels with $\geq 75\%$ stenosis. LVEF was truncated such that patients with an LVEF $\geq 60\%$ were analyzed as having an LVEF of 60%.

Results

Baseline Characteristics

The study sample was composed of 80 patients, ranging in age from 32 to 86 years (57 ± 11 years), and was 65% male and 69% Caucasian. The sample showed moderate rates of comorbidity with 59% of patients reporting a history of hypertension, 24% with diabetes, 15% with chronic obstructive pulmonary disorder (COPD), and 7% with congestive heart failure.

Seventy-three percent of patients reported a history of smoking and 57% were current smokers. Sixteen percent had a history of MI, 17% had a previous coronary artery bypass graft (CABG), and 15% had a history of percutaneous transluminal coronary angioplasty (PTCA). Ninety-four percent of patients had received PTCA for revascularization during their current hospitalization.

Diary Stress and VPBs

Patients made an average of approximately 34 entries during their 24-hour monitoring (mean entries = 33.6 ± 4.6 (range: 20-50)). All holter monitoring assessments had at least 21.9 hours of data (mean hours = 23.9 ± 0.3). Consistent with previous studies among cardiac patients (16), forty-one patients (51.3%) did not report diary stress during their assessment. Patients reporting stress also were more likely to have 3-vessel disease at the time of their index MI, and showed higher scores on both state and trait anxiety (see Table I).

In order to evaluate whether stress and anxiety were related to ventricular ectopy independently of other known predictors, a model was created that included factors identified a priori as predictors of ventricular arrhythmias: age, gender, LVEF, and CAD severity. After adjusting for these covariates, mean diary-reported stress ($\beta = .29$, $p = .01$) or state anxiety ($\beta = .24$, $p = .04$) was significantly associated with total VPBs over the 24-hour period (Fig 2-3). Trait anxiety, however, was not related to total VPBs ($\beta = .16$, $p = .20$).

Twenty-five patients (31%) in the current sample experienced repetitive VPBs (bigeminy, trigeminy, salvo, or VT) during their assessment. Patients with repetitive VPBs reported more stress ($F_{(1,79)} = 5.71$, $p = .02$) and experienced more total VPBs ($F_{(1,79)} = 68.77$, $p < .0001$), although the groups did not differ in the amount of state ($F_{(1,79)} = 0.32$, $p = .57$) or trait anxiety ($F_{(1,79)} = 0.79$, $p = .38$) reported.

Temporal analysis

Results from the temporal analysis of stress and VPBs are shown in Table II. Temporal analysis of the relationship between stress and VPBs showed that diary-reported stress was associated with a significant increase in VPBs in the following hour ($B = 0.74$, $p < .0001$). In order to evaluate the magnitude of this effect, diary entries without stress were compared with entries containing a 'mild' endorsement of stress (score of 2 on a 4-point Likert scale). Diary entries without stress were associated with approximately 254 VPBs in the following hour, whereas a 'mild' endorsement of stress was associated with approximately 530 VPBs in the following hour.

Discussion

The present study found that the frequency of ventricular ectopy 12 weeks following MI was associated with daily stress levels and state anxiety, such that patients reporting more stress or greater state anxiety experienced more ectopic beats. Trait anxiety, however, was not associated with VPBs. Our findings also demonstrated a temporal relationship between stress and VPBs such that diary-reported stress significantly predicted VPBs in the subsequent hour period. This finding extends previous evidence from prospective studies that have shown that psychological factors such as negative affect, distress, and low social support are associated with ventricular arrhythmias (6,11,17-20). Moreover, our observations are unique in that they are based upon the assessment of both stress and ventricular ectopy during a typical 24-hour period following MI. Previous studies investigating psychological stress in acute post-MI patients have reported positive associations with VPBs but have either done so in the laboratory setting (2) or prospectively using personality measures administered during hospitalization (12).

Prior research has shown that the frequency of VPBs may be prognostic of subsequent sudden cardiac death (SCD) among post-MI patients (12,21) although this relationship is thought to be mediated by LV dysfunction (10). Previous investigations have also found that ischemia may cause increased rates of arrhythmias through disturbances in ion concentrations, accumulation of arrhythmogenic metabolites, or metabolic changes which disrupt conduction at the cellular level (22). The current findings suggest that stress also predicts ventricular ectopy and that these effects remain significant after adjusting for the effects of LVEF and extent of CAD. Our findings differ from those reported in previous studies among CHF patients (8), which demonstrated that the association between psychological stress and ventricular arrhythmias is dependent on cardiac function assessed by LVEF. However, the exclusion criteria for the current study, which precluded patients with LVEF < 30% from participating, prevented an investigation into the mediating role of low LVEF in this sample. This finding that CAD severity may be more strongly associated with VPBs than LVEF is consistent with previous research showing that the relatively higher risk of mortality associated with LV dysfunction may be mediated by CAD severity (23).

Approximately 40% of the CHD population experiences repetitive VPBs (1) and more complex ventricular arrhythmias that constitute repetitive VPBs may only be observable upon more extensive holter monitoring (24). Patients exhibiting complex ventricular arrhythmias are significantly more likely to have higher frequencies of VPBs and patients with increased frequency of VPBs are more likely to experience complex ventricular arrhythmias, such as ventricular tachycardia (VT) (24). Furthermore, CHD patients with more complex ventricular ectopy tend to show greater overall levels of VPBs and are at higher risk for mortality, especially in the presence of MI (25). We found that individuals experiencing repetitive VPBs also experience greater levels of psychological stress, but that state and trait anxiety were not elevated in this subset of patients.

Our finding that state anxiety and stress were associated with total VPBs while trait anxiety was not, conflicts with previous studies demonstrating an association between trait psychological factors and VPBs (11,26). It is possible that previous studies showing that trait-level psychological factors were associated with an increased incidence of arrhythmias may have been influenced by state-dependent factors associated with peri-hospitalization events (26). Previous studies have utilized relatively brief assessment periods (11) or have relied on group comparison with medical controls (26). Moreover, the measurement of trait-level psychological constructs such as perceived social support (27), distress (11), and depression may have been confounded by state-dependent factors (19). Experimental studies manipulating state-dependent psychological factors have demonstrated an association between induced states of emotional arousal and increased levels of VPBs (2,29), indicating that changes in arousal, not trait levels, may be associated with increased levels of VPBs.

The relationship between stress and anxiety is complex and poorly defined. Because of the inherent difficulty in differentiating between these interrelated constructs, previous metaanalyses investigating the relationship between psychological stress and CHD have separated this term into related subcomponents such as phobic anxiety, depression, and hostility (30). Anxiety has conventionally been construed as a more chronic, anticipatory state of arousal (31), whereas stress is characterized by an acute psychological reaction to an emotional stimulus (32). Trait-level anxiety reflects individual differences in the tendency to respond with state anxiety in the anticipation of threatening situations (15). Although both emotions are characterized by a heightened state of emotional arousal in the face an aversive stimulus, a cognitive appraisal of threat is characteristic of anxiety (32), whereas stress is characterized by an acute response that is less influenced by cognition (33). Anxiety and stress may be interrelated in that one might experience anxiety as a symptom following a stressful event, as a cognition in responding to a stressful event, or as an accompanying emotion (34). More recent

definitions of stress have noted that stress can be cognitively mediated, so that the perception of a stressor is influenced by individual differences in appraisal (35). At a general level, stress may be thought of as a reactive state, whereas anxiety may be thought of as an anticipatory state.

The present findings should be viewed with several limitations in mind. First, our analysis of the relationship between psychosocial factors and VPBs evaluated this relationship over a 24-hour period. Because ECG recordings continued during the night, nocturnal arrhythmias were included in our calculation of VPBs, although diary-reported stress was evaluated only during waking hours. There is some evidence to suggest that the frequency of arrhythmias is significantly lower during sleep compared with waking states among CHD patients (1) but these findings are inconsistent (36). In the current sample, the exclusion of nocturnal ectopy did not alter our findings. Additionally, patients who reported stress during their assessment were less likely to be taking beta-blockers as compared to patients who did not report stress ($p = .04$). A post hoc analysis, however, demonstrated that the relationship between stress and VPBs was not significantly altered after controlling for beta-blocker usage.

The present study may have important implications for the clinical management of post-MI patients. Previous studies of cardiac patients have shown that self-reported levels of anger precipitate implantable cardio-defibrillator (ICD) discharge (20), but the temporal association between VPB rates and mood has yet to be investigated. Although no patients in the current sample reported palpitations, the possibility of somatic symptoms eliciting stressful diary responses cannot be discounted. Previous studies have reported that male post-MI patients admitted to being aware of irregularities of their heartbeat during holter monitoring when questioned, although their responses were not readily reported (37). Further research is needed evaluate the relationship between psychosocial factors and ventricular ectopy among ambulatory post-MI patients.

In summary, the present findings suggest that the experience of psychological stressors during daily life may be associated with increased ventricular ectopy in patients with CHD. Although levels of anxiety experienced at the beginning of 24-hour monitoring were also predictive of ventricular ectopy, trait anxiety was not associated with increased amounts of ectopy. These findings underscore the importance of psychological stress during daily life as a risk factor for ventricular ectopy in CHD patients.

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Figure 1.
Flow chart showing numbers of patients available, and numbers meeting exclusion and inclusion criteria for study.

Stress and VPBs

Figure 2.
Diary-reported stress and VPBs among patients who reported stress.

Anxiety and VPBs

Figure 3.
State anxiety and VPBs among patients who reported stress.

Table I

Demographic and clinical characteristics of patient sample and of groups stratified by mean diary stress. Values represent the mean $\pm$ 1 S.D.

	All patients	Stress Absent	Stress Present
Age (years)	57 $\pm$ 11	57 $\pm$ 12	56 $\pm$ 10
Gender (% Male)	65	66	64
Race (% Caucasian)	69	63	74
LVEF (%)	51 $\pm$ 8	51 $\pm$ 9	51 $\pm$ 8
3-vessel coronary artery disease	14%	7%	21% [†]
Body Mass Index (kg/m ²)	29 $\pm$ 6	29 $\pm$ 6	30 $\pm$ 5
Peak CKMB during hospitalization	115 $\pm$ 112	115 $\pm$ 128	115 $\pm$ 116
Medications (%)			
β Blockers	88	95	80 [*]
ACE inhibitors	79	78	80
Calcium channel blockers	13	10	15
VPBs/24 hours	701 $\pm$ 1619	594 $\pm$ 1462	815 $\pm$ 1782 ^{**}
State Anxiety	28.3 $\pm$ 10.4	24.3 $\pm$ 7.5	32.6 $\pm$ 11.5 ^{**}
Trait Anxiety	30.1 $\pm$ 10.9	25.6 $\pm$ 5.7	34.8 $\pm$ 13.0 ^{**}

LVEF, left ventricular ejection fraction; CKMB, creatine kinase MB isoenzyme; VPB, ventricular premature beat.

[†] Contrasted with patients without stress; $p < .10$

^{*} Contrasted with patients without stress; $p < .05$

^{**} Contrasted with patients without stress; $p < .001$

Table II

Temporal association between diary-reported stress, posture, and ventricular ectopy. B-values represent the unstandardized covariance between diary-reported factors and log-transformed VPBs in the following hour.

		B	95% CI	p
Stress		0.74	0.50-0.99	<.0001
Posture	Supine	-0.30	-0.63-0.03	.075
	Sitting		(<i>Reference Posture</i>)	
	Standing	-0.39	-0.59--0.18	<.001