Anger and Hostility Predict the Development of Atrial Fibrillation in Men in the Framingham Offspring Study

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Background—Conflicting findings in the literature with regard to the ability of type A behavior, expressions of anger, or hostility to predict incident coronary heart disease (CHD) have created controversy. In addition, there are no prospective studies relating these characteristics to the development of atrial fibrillation (AF).

Methods and Results—From 1984 to 1987, 3873 men and women, 18 to 77 years of age, participating in the Framingham Offspring Study, were examined and monitored for 10 years for the incidence of CHD, AF, and total mortality. Measures of type A behavior, anger, hostility, and risk factors for CHD and AF were collected at the baseline examination. After controlling for age, diabetes, hypertension, history of myocardial infarction, history of congestive heart failure, and valvular heart disease in Cox proportional hazards models, trait-anger (RR=1.1; 95% CI, 1.0 to 1.4; $P=0.04$), symptoms of anger (RR=1.2; 95% CI, 1.0 to 1.4; $P=0.008$), and hostility (RR=1.3; 95% CI, 1.1 to 1.5; $P=0.003$) were predictive of 10-year incidence of AF in men. After controlling for risk factors for CHD, none of the measures of anger, type A behavior, or hostility were related to incident CHD; however, trait-anger (RR=1.2; 95% CI, 1.1 to 1.4; $P<0.01$) was related to total mortality in men. None of the psychosocial variables were related to the 3 outcomes in women.

Conclusions—This is the first study to examine and demonstrate a predictive relation between measures of anger and hostility to the development of AF in men. As opposed to type A behavior, measures of anger and hostility may be more productive avenues for research in studying the risk of arrhythmias and total mortality in men. **(*Circulation*. 2004;109: 1267-1271.)**

Key Words: coronary disease ■ fibrillation ■ mortality ■ men ■ arrhythmia

There is conflict in the literature with regard to whether psychosocial factors predict the development of coronary heart disease (CHD) and total mortality. For example, most studies of type A behavior show no association between type A and the development of definite CHD,[1–5] but some demonstrate positive results.[6–8] Evidence for an association between anger and CHD is limited but suggestive,[9,10] but there appear to be no prospective studies of anger and total mortality. Findings from studies of hostility and cardiovascular atherosclerosis demonstrate both negative[11] and positive[12,13] findings. Several prospective cohort studies of men examined the associations between hostility, incident CHD, and total mortality.[14–17] Two of these studies found no association between hostility, incident CHD, or total mortality,[14,15] and 2 demonstrated positive findings.[16,17] There is a deficit of prospective studies of hostility and CHD or total mortality in women, but one case-control study of women found that a measure of hostility was significantly associated with the presence of CHD.[18]

Hence, the role of psychological factors in the development of CHD and mortality is controversial. Furthermore, to our knowledge, the relation between psychosocial characteristics and incident atrial fibrillation (AF) has never been examined. The objective of our study, therefore, was to test the hypotheses that type A behavior, measures of anger, and hostility were independently related to the 10-year incidence of CHD, AF, and total mortality in men and women.

Methods

The Framingham Heart Study is a prospective, longitudinal cohort study that began enrollment of the offspring (and spouses) of the original Framingham Heart Study cohort in 1971.[19] From 1984 through 1987, 3873 offspring participants returned for their third follow-up examination. A few weeks before the examination, subjects were mailed psychosocial questionnaires, which were collected at the scheduled clinic visit; 95% were completed. Subjects were excluded from the present study for the following indications: incomplete questionnaire (n=191), prevalent CHD for the analyses of incident CHD (n=107), and prevalent AF (n=25) for the analyses of incident AF.

The Bortner Rating Scale for behavior type (type A/type B) has been found to be related to incident CHD[8] and was introduced into the Framingham Offspring Study in 1984. The Bortner Rating Scale has 14 items, each comprising 2 statements with a 7-point Likert scale in between the 2 statements. Examples include "never late" on

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TABLE 1. Relation of Type A, Anger, and Hostility Scales to CHD Risk Factors: Men

	Pearson Correlation Coefficients					Mean Scores: Cigarette Smokers		Mean Scores: Diabetes	
	Age	Education	Systolic Blood Pressure	Body Mass Index	Total-C/HDL-C	No	Yes	No	Yes
Bortner Rating Scale Type A behavior	−0.10	0.003	−0.03	0.03	−0.03	0.48	0.48	0.48	0.48
P	0.0001*	0.91	0.31	0.18	0.26	0.62		0.96	
Trait-anger	−0.09	−0.08	−0.01	0.09	0.03	0.23	0.26	0.24	0.26
P	0.0002*	0.001*	0.58	0.0003*	0.28	0.0001*		0.19	
Symptoms of anger	−0.06	−0.05	−0.04	−0.04	0.02	0.22	0.24	0.23	0.24
P	0.02*	0.05*	0.11	0.13	0.33	0.20		0.47	
Anger-in	−0.002	−0.01	−0.02	−0.03	0.001	0.34	0.36	0.34	0.36
P	0.92	0.63	0.31	0.28	0.96	0.23		0.50	
Anger-out	−0.10	0.04	−0.03	0.003	0.007	0.15	0.14	0.15	0.16
P	0.0001*	0.08	0.15	0.90	0.77	0.79		0.48	
Anger-discuss	−0.06	0.02	−0.04	0.04	0.02	0.47	0.47	0.48	0.50
P	0.01*	0.48	0.10	0.08	0.37	0.14		0.58	
Hostility	0.05	−0.25	0.03	0.15	0.09	0.47	0.50	0.47	0.52
P	0.05*	0.0001*	0.21	0.0001*	0.0002*	0.003*		0.08	

Total-C/HDL-C indicates total cholesterol/HDL cholesterol.
*$P<0.05$.

one end of the scale and "casual about appointments" on the other end of the scale. The participant put a check between the two descriptors to indicate what best described him or her.

Anger was assessed through the use of the original Framingham scales for Anger-In, Anger-Out, Anger-Symptoms, and Anger-Discuss.[20] These anger scales assessed ways of expressing or coping with anger, such as keeping it to oneself ("anger-in"), taking it out on others ("anger-out"), or talking with a friend or relative ("anger-discuss"). The physical manifestations of anger included such things as getting a headache or feeling weak ("anger-symptoms"). In addition, the 10-item Spielberger Trait-Anger Scale[21] has been found to significantly predict the development of CHD in a large prospective study[9] and was included in our study. On the Spielberger scale, participants rated their typical experience with anger on a 4-point Likert scale. A measure of hostility consisted of selected items from the Cook-Medley Hostility Scale.[13] These selected items were based on the research of Williams et al, demonstrating that patients endorsing these items were more likely to have coronary occlusions.[13] The Cook-Medley hostility items are characterized by the view that others are inconsiderate, immoral, selfish, and deserving to be punished or hurt. Responses consisted of agreement or disagreement with various statements. The reliability and validity of the particular items selected, relative to the entire hostility subscale, are not known.

For all psychosocial scales, responses were scaled and standardized between 0 and 1, with the higher score indicating more of the trait. A scale score was obtained by calculating an average over the nonmissing values in the scale.

The 3 outcomes of interest included the 10-year incidence of CHD, AF, and total mortality. The definitions of CHD[22] and AF[23] have been published previously; the manifestations of interest for CHD in these analyses included myocardial infarction (recognized and unrecognized), coronary insufficiency, and coronary death (both sudden and not sudden). The diagnosis of AF was made if AF or atrial flutter was present on an ECG obtained from the Framingham clinic visit, hospital charts, or physician office record. Atrial fibrillation was diagnosed if p-wave activity was not evident and the ventricular response was irregularly irregular. Atrial flutter was diagnosed if typical flutter (saw-tooth) waves were seen on the ECG. AF electrocardiograms were reviewed and verified by one of two Framingham Study cardiologists. For causes of death, 25% of men and 12% of women died from coronary heart disease. Cerebrovascular accidents accounted for 2.8% and 4.4% of deaths in men and women, respectively. Cancer accounted for 35.4% of deaths in men and 55.4% of deaths in women.

Potential confounders were ascertained at the index examination. Multivariable models predicting the 10-year incidence of CHD and total mortality adjusted for age, systolic blood pressure, body mass index (kg/m^2), current cigarette smoking, diabetes (defined as fasting blood glucose of at least 126 mg/dL or on treatment), total cholesterol/high-density cholesterol. Multivariable analyses for AF included characteristics known to be related to its development: age, diabetes, hypertension, history of myocardial infarction or history of congestive heart failure, and valvular heart disease (defined as any diastolic murmur or $\geq$3 out of 6 systolic murmur).

All analyses were sex specific. We examined the relation of the psychosocial measures to education and CHD risk factors classified at baseline with Pearson correlations and ANOVA for continuous and discrete variables, respectively. The 10-year age-adjusted rates and relative risks of CHD, AF, and total mortality were estimated by means of Cox proportional hazards regression. For each psychosocial predictor variable that reached a significance level of $P\leq0.10$ in the age-adjusted analyses, we examined multivariable-adjusted Cox proportional hazards models. Relative risks for incident disease were presented relative to a 1-SD difference in each measure. In exploratory analysis, we also investigated the impact of adjusting for interim myocardial infarction and interim coronary heart failure in the models for AF.

The Office of Management and Budget approved the use of this survey in the Framingham Offspring Study in 1983.

Results

The study consisted of 1769 men and 1913 women who were a mean age of 48.5 (SD=10.1; range, 18 to 77 years) at baseline. Table 1 and Table 2 present the Pearson correlation coefficients between the measures of type A behavior, anger,

TABLE 2. Relation of Type A, Anger, and Hostility Scales to CHD Risk Factor: Women

	Pearson Correlation Coefficients					Mean Scores: Cigarette Smokers		Mean Scores: Diabetes	
	Age	Education	Systolic Blood Pressure	Body Mass Index	Total-C/ HDL-C	No	Yes	No	Yes
Bortner Rating Scale Type A behavior	−0.15	0.01	−0.12	−0.04	−0.06	0.47	0.47	0.47	0.45
P	0.0001*	0.58	0.0001*	0.07	0.01*	0.96		0.34	
Trait-anger	−0.20	0.02	−0.10	0.03	−0.002	0.22	0.24	0.23	0.22
P	0.0001*	0.52	0.0001*	0.26	0.93	0.008*		0.83	
Symptoms of anger	0.04	−0.15	0.04	0.07	0.09	0.35	0.38	0.36	0.39
P	0.13	0.0001*	0.12	0.004*	0.0003*	0.01*		0.31	
Anger-in	0.10	−0.13	0.07	0.03	0.08	0.33	0.35	0.33	0.40
P	0.0001*	0.0001*	0.004*	0.22	0.001*	0.07		0.09	
Anger-out	−0.19	0.11	−0.10	−0.01	−0.04	0.15	0.14	0.15	0.11
P	0.0001*	0.0001*	0.0001*	0.78	0.10	0.27		0.17	
Anger-discuss	−0.11	0.05	−0.07	−0.02	−0.003	0.61	0.61	0.61	0.63
P	0.0001*	0.05*	0.002*	0.51	0.90	0.80		0.77	
Hostility	−0.08	−0.13	−0.07	−0.01	−0.02	0.39	0.43	0.40	0.43
P	0.0006*	0.0001*	0.001*	0.59	0.46	0.0002*		0.30	

Total-C/HDL-C indicates total cholesterol/HDL cholesterol.
*$P<0.05$.

hostility, and education and the CHD risk factors for men and women, respectively. In men and women, most of the scales were inversely associated with advancing age except hostility, which was positively associated with age in men. Hostility was inversely related to education and directly associated with smoking in both men and women. Hostility also was directly related to body mass index and total/HDL cholesterol in men. In contrast to men, in women many of the scales were negatively associated with blood pressure. In addition, trait-anger was positively associated with smoking in women.

Table 3 shows the age-adjusted relations between the type A, anger, and hostility variables to the 10-year incidence of CHD, AF, and total mortality in men and women. None of the measures of type A behavior, anger, or hostility reached statistical significance for men or women in relation to incident CHD. Because previous research has shown that anger may have a differential effect by housewife/working woman status,[2] we reanalyzed the model in women stratifying on this characteristic; the results were not materially altered (data not shown).

In age-adjusted analyses of AF, increased trait-anger, hostility, and symptoms of anger were significant predictors in men, and anger-out was a significant predictor in women. Trait-anger was positively associated with the age-adjusted total mortality rate in men. None of the variables examined were associated with total mortality in women.

TABLE 3. Age-Adjusted Relative Risks for 10-Year Occurrence of Coronary Heart Disease, Atrial Fibrillation, and Total Mortality

	Coronary Heart Disease		Atrial Fibrillation		Total Mortality	
	Men	Women	Men	Women	Men	Women
No. of events/persons at risk	126/1680	47/1895	132/1750	62/1908	175/1769	92/1913
RR (95% CI)						
Bortner–type A	1.1 (0.9–1.3)	0.9 (0.7–1.2)	1.1 (0.9–1.3)	1.1 (0.8–1.5)	1.0 (0.9–1.2)	0.9 (0.7–1.2)
Trait-anger	1.1 (0.9–1.3)	0.8 (0.5–1.1)	1.2 (1.0–1.4)*	1.1 (0.9–1.4)	1.2 (1.0–1.4)*	0.9 (0.7–1.1)
Hostility	1.1 (0.9–1.3)	1.0 (0.7–1.3)	1.3 (1.1–1.6)*	1.2 (0.9–1.5)	1.2 (1.0–1.3)	1.1 (0.8–1.3)
Symptoms of anger	1.1 (1.0–1.3)	1.0 (0.8–1.4)	1.2 (1.1–1.4)*	1.0 (0.8–1.3)	1.1 (0.9–1.2)	0.8 (0.7–1.1)
Anger-in	1.0 (0.9–1.2)	1.2 (0.9–1.5)	0.9 (0.8–1.1)	1.1 (0.9–1.4)	0.9 (0.8–1.1)	1.2 (1.0–1.4)
Anger-out	1.1 (0.9–1.3)	0.8 (0.5–1.1)	1.0 (0.9–1.2)	1.3 (1.0–1.6)*	1.1 (0.9–1.2)	1.0 (0.8–1.3)
Anger-discuss	1.1 (0.9–1.4)	1.1 (0.8–1.5)	1.2 (1.0–1.4)	1.2 (0.8–1.5)	1.1 (1.0–1.3)	0.9 (0.7–1.1)

Relative risks are expressed per 1-SD change in the scale scores.
*Relations significant, $P<0.05$.

TABLE 4. Multivariable Adjusted Relative Risks for 10-Year Occurrence of Atrial Fibrillation and Total Mortality in Men

	Atrial Fibrillation		Total Mortality	
	Adjusted RR	95% CI	Adjusted RR	95% CI
Trait-anger	1.1*	1.0–1.4*	1.2*	1.1–1.4*
Hostility	1.3*	1.1–1.5*	NA	NA
Symptoms of anger	1.2*	1.0–1.4*	NA	NA

Relative risks are expressed per 1-SD change in scale scores.
*Relations significant, $P<0.05$.
NA indicates not significant.

The multivariable analyses for the 10-year incidence of AF and total mortality in men are presented in Table 4. Men with increased trait-anger were at significantly higher risk of developing AF (RR=1.1; 95% CI, 1.0 to 1.4; $P=0.04$), as were those with increased hostility (RR=1.3; 95% CI, 1.1 to 1.5; $P=0.003$) or increased symptoms of anger (RR=1.2; 95% CI, 1.0 to 1.4; $P=0.008$). When interim myocardial infarction or congestive heart failure (during the follow-up) was taken into account, the symptoms of anger and hostility variables remained significant predictors of AF (data not shown). For total mortality, men with increased trait-anger had a relative risk of death of 1.2 (95% CI, 1.1 to 1.4; $P<0.01$) for each standard deviation increase in scale scores for trait-anger. Anger-out in women was no longer significantly related to AF in the multivariable model.

We examined the clinical features of the AF cases in our study. More than half the cases (66%) occurred before the age of 60 years. Ninety-nine percent of all AF cases had no history of CHF at baseline, and 87% of cases were free of CHF during the follow-up. Ninety-two percent of AF cases were free of myocardial infarction at baseline, and 86% were free of myocardial infarction during the follow-up.

Discussion

To our knowledge, our study is the first to systematically examine the predictive relation between psychosocial variables and incident AF in a large prospective cohort. Noteworthy findings from our study are that in men, symptoms of anger and hostility were predictive of incident AF after adjusting for baseline and interim risk factors. It is important to place our AF findings in context. The peak ages for the prevalence of AF are from 70 to 84 years of age.[24] The cases we observed in this particular study could be characterized as "early-onset" or "premature" AF, largely occurring without preexisting heart disease. Thus, risk factors for the early development of AF in men appear to be strongly associated with psychosocial risk factors such as anger and hostility.

Progress is being made in defining the role of behavioral and emotional stress in the precipitation of cardiac arrhythmias.[25–30] Studies of animals have demonstrated that cardiac arrhythmias were significantly more frequent during social stress than during other challenging situations.[25] A recent study in humans found that anger (OR, 1.8; 95% CI, 1.0 to 3.2) can trigger ventricular arrhythmias in patients with implantable cardioverter-defibrillators.[28]

Our findings with regard to trait-anger and incident CHD differ from prior studies. We found trait-anger to be significantly related to total mortality in men but not incident CHD. Other studies have found that trait-anger[10] or "anger-content"[9] to be related to incident CHD. The latter study showed significance only after angina pectoris was included in the CHD outcomes.

In the original Framingham Study cohort, it was found that type A behavior was significantly related to angina pectoris but not myocardial infarction or fatal coronary artery disease in both men and women.[1] This finding explains the discrepancies between this report and earlier publications from the original Framingham cohort.[31] In the present study, angina pectoris was not included as an end point, only definite CHD. As with most prospective studies of type A behavior, the present study of the Bortner scale for type A behavior did not predict definite CHD, AF, or total mortality. In contrast, the VA Normative Aging Study found the MMPI-2 Type A Scale predicted CHD incidence.[7] This inconsistency probably is due to the conceptualization of type A behavior and how it is measured.

With regard to women, the findings from the present offspring study are similar to those reported previously in the Framingham cohort.[2] The Framingham scales for anger symptoms, anger-in, anger-out, and anger-discuss were not associated with the incidence of myocardial infarction or coronary death. In the present study, we added trait-anger and hostility, and neither of these variables reached statistical significance for any of the three end points in women. Another research study has shown that "suppressed anger" is not related to nonfatal myocardial infarction in men or women.[32]

There is little consensus among previous prospective cohort studies on the effect of hostility on total mortality or incident CHD.[14–17] The present study is in agreement with two other prospective studies[14,15] that failed to support an association between hostility and incident CHD or total mortality. It has been argued that adjusting for potential confounders may be inappropriate and may lead to an erroneous conclusion with regard to hostility.[33] This probably is not the case with the present analyses because even the age-adjusted analyses of hostility did not achieve statistical significance for CHD or total mortality. Some studies have argued that hostility rather than type A behavior is the important risk factor for disease.[34–36] Two of these studies are matched case-control studies,[34,36] and one is a cross-sectional study of peripheral arterial disease.[35]

The strengths of the Framingham Offspring Study include a prospective design, inclusion of both men and women, a stable cohort, carefully assessed end points, and routinely ascertained information on standard risk factors. One potential limitation is that the psychometrics of the abbreviated measure of hostility used in the present study are not known; its predictive value, however, for AF appears to be adequate in men. Certainly, replication of our findings is necessary before we can generalize the idea that hostility is an etiologic factor for early-onset AF in men; this is particularly important because the effect size that we observed (a maximum relative risk of 1.3) is modest. In addition, the study cohort was

predominantly white and middle-aged; the findings may not be generalizable to other ethnicities and the elderly. Because our community sample is middle aged, the event rates were low in women, which limited our power to describe the predictive relations of psychosocial characteristics to these end points (eg, we had power of 29% to detect a relative risk of 1.8 of CHD in women). Our sample in the Framingham Offspring Study, however, constitutes one of the larger data sets with prospective psychosocial data in women.

In summary, we did not observe significant associations between anger, type A behavior, and hostility for the 10-year incidence of CHD, AF, or total mortality in women. For men, however, trait-anger, hostility, and symptoms of anger are independent risk factors for the development of AF. Although hypotheses about emotions and the development of arrhythmias were reasonable, this is the first time an association has been documented specifically between emotions and the development of AF. In addition, trait-anger is also an independent risk factor for total mortality in men. The mechanism of the relation between AF and anger and hostility merits further investigation. Future interventions for the prevention of early onset of AF in men might include anger and hostility recognition and management.

Acknowledgments

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