



Type D Personality as a Risk Factor for Repeated Episodes of Coronary Artery Spasm

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Abstract

Objective: The purpose of this study was to examine the association between Type D personality and repeated episodes of coronary artery spasm.

Design: Using a quasi-experimental design, with 44 coronary artery spasm patients, Type D and non-Type D personality patients were compared. Demographic, clinical, and psychological data was collected. Hypothesis testing, correlation matrix, single regression, multiple regression, and logistic regression analysis were used to examine the relationship between Type D personality and repeated episodes of coronary artery spasm while adjusting for demographic, clinical, and psychological factors.

Main outcome measures: This study assessed the impact of Type D personality on repeated episodes of coronary artery spasm.

Results: The probability of experiencing repeated episodes of coronary artery spasm requiring medical attention was greater among patients who had a Type D personality, d=.27, p =.022, 95% CI [.0385548, .506900], z=2.28. Patients who had a Type D personality were more likely to experience anxiety and depression disorder. Smoking was a predictor of coronary artery spasm among patients who had a Type D personality; (F(1,19) = 5.47, p = .033).

Conclusions: Type D personality is a predictor of coronary artery spasm and a risk factor for repeated episodes of coronary artery spasm requiring medical attention.

Keywords: Type D personality; Coronary artery spasm; Repeated episodes coronary artery spasm; Multiple regression

Introduction

The belief that personality is linked to health and disease can be traced back to 160 AD and Galen, a Greek physician who proposed that diseases and behaviors were associated with a person's body fluid, with the dominant fluid determining personality type [1,2]. Scientific studies have provided empirical evidence that shows that there is a causal association between personality and health and disease [3]. Personality is closely linked to different physical ailments and diseases as well as psychological disorders [4]. Personality has a significant impact on the physiology of an individual [5]. This impact is largely attributed to the effect that brain structures associated with personality have on the physiology of an individual and its influences on somatic diseases such as cardiovascular disease [5].

Personality constructs represent real life phenomena, have a causal relationship to their measure and have scientific implications for the progress of psychology and the explanation of behavior [6]. Personality constructs provide important information and advance the understanding of the association between assessment and intervention [6]. They help organize the intricacies and learning of real life situations, events, and phenomena [6] and are key predictors of outcomes [7]. Personality constructs are clinically useful [8], supported by scientific evidence, and critical for the advancement of behavioral science, psychology, and medicine [6].

The genesis of the ABCD personality constructs is attributed to two American cardiologists, Dr. Meyer Friedman and Dr. R. H. Rosenman. They introduced the Type A construct, which was developed from clinical observation and proposed that individuals who are ambitious, impatient, and status conscious are at higher risk of heart failure [9]. The Type A construct was later expanded to become the Type A and Type B personality constructs where a Type B was the psychological opposite of a Type A, characterized by tolerance, patience, stability, and calmness [4,10]. The Type C personality construct, attributed to Dr. Lydia Themoshok and Henry Dreher and derived from their mind-body studies [11], is characterized by repressiveness, suppressed feelings, vigilantism, and stress [4]. It is linked to risk factors for cancer, particularly breast cancer [4]. The Type D personality construct was founded by Dr. Johan Denollet, professor of Medical Psychology at Tilburg University in the Netherlands based on clinical work and observations with cardiac patients [12].

The relationship between personality and diseases and conditions of the heart is well documented [5]. There is a clear linkage between coronary-prone personality type and behavior pattern as well as health and health maintenance [3]. Theories of personality and scientific evidence point to Type D personality as a risk factor for coronary heart diseases [13]. The Type D personality construct is characterized by negative affectivity and social inhibition and is a predictor of poor outcomes in cardiovascular health [12]. Psychological attitudes such as the inherent traits of Type D personality are connected to cardiovascular disease [14]. Tindle, Davis and Kuller proposed that understanding

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the dynamics of psychological attitudes and cardiovascular disease is important for its treatment.

The Type D personality construct suggests that health and health outcomes are linked to personality type [15]. Individuals who have a Type D personality have a four to six times higher risk of having anxiety and depression [16], five times higher risk for poor mental health [17], and four times higher risk of recurrent cardiac episodes [18] compared to individuals who do not have a Type D personality. Individuals who have a Type D personality are at a significantly higher risk of myocardial infarction and have a poorer prognosis following a myocardial infarction [15]. They also have more cardiovascular-related health problems compared to individuals who do not have a Type D personality [19].

Type D personality is a known risk factor for premature, cardiacrelated death [20]. Type D personality has been linked to many cardiovascular conditions that strain, weaken, debilitate, and damage the heart muscle as well as serious cardiac outcomes; heart arrhythmias [21], chronic heart failure [22], coronary artery disease [23], hypertension [24], myocardial infarction [25], and peripheral arterial disease [26]. While the relationship between Type D personality and coronary heart disease [9] has been well established, its relationship with coronary artery spasm, a cardiovascular event and a source of coronary angina or chest pain, has not.

Chest pain is the primary reason patients seek medical consultation worldwide [27]. A number of disorders including cardiovascular, gastrointestinal, musculoskeletal, psychological, and pulmonary [28], can cause chest pain (angina). Coronary artery spasm, also known as coronary vasospasm, vasopastic angina, or Prinzmetal's angina, is an important etiology of chest pain that has been linked to adverse outcomes [29]. Coronary artery spasm, is unexpected angina due to a sudden reversible constriction of a coronary artery that restricts the coronary blood flow causing occlusion or near occlusion (myocardial ischemia) and results in excruciating pain in the chest area [29,30].

Coronary artery spasm results in the sudden and temporary constriction of the arteries that supply blood to the heart muscle and leads to the starvation of oxygenated blood. It is linked to coronary artery disease [31] and is a serious cardiac event that can cause severe chest pain, diminished functionality of the heart muscle, and may result in myocardial infarction and sudden death [32]. Coronary artery spasm can strain and weaken the heart muscle and is a precipitant of myocardial ischemia in patients with or without atherosclerosis [33]. It is a significant factor in the pathogenesis of ischemic heart disease and among the most significant clinical abnormalities of the coronary artery [34].

Epidemiology data shows a prevalence rate of 40% among Japanese patients, 50% among Asian patient that do not present obstructive coronary artery disease, 57% among Asian patients that do present obstructive coronary artery disease [7], and 4% in the United States [25]. The prevalence rate in Western countries is a fraction of what it is in Asian countries [2,26]. This is explained by the fact that in Western countries, coronary artery spasm is often overlooked and underdiagnosed because the condition can be confused with atherosclerosis, the primary reason for coronary disorders [27]. Its diagnosis is often missed because its symptoms are similar to that of myocardial infarction; chest pain, EKG changes, blood flow restriction, atypical myocardial damage and because its incidence is rare, sporadic, infrequent, and not well understood [7,27,28]. Under provocation testing, multiple coronary artery spasms are diagnosed at a rate of 24.7% among Japanese patients, 19.3% among Taiwanese patients compared to 7.4% among United States patients [7]. The incidence of coronary artery spasm diagnosis in the United States and Western countries has been declining over the last three decades [29]. This may be due to the increase of effective treatments such as calcium channel blocker and underreporting due to doctors performing less confirmatory provocative testing as a result of insurance and reimbursement pressures [29].

It has been found that psychological risk factors such as anxiety, depression, occupational status, social support, and stress play a significant role in the onset, development, length, and outcome of coronary artery disease [35-40]. For coronary artery spasm specifically, age, gender, ethnicity [7], history of angina (severe chest pain) at rest, history of stenosis (narrowing of blood vessel) [8], history of smoking [9], alcohol [3], and illicit drug use [10] are known risk factors, however, little is known about other clinical and psychological features such as personality as a risk factor [8]. This study evaluated the association between Type D personality and coronary artery spasm and explored Type D personality as a predictor of repeated episodes of coronary artery spasm.

Study Overview

Age, gender, ethnicity [7], history of angina (severe chest pain) at rest, history of stenosis (narrowing of blood vessel) [9], history of smoking [3], alcohol [10], and illicit drug use [8] are known risk factors for coronary artery spas, however, little is known about other clinical and psychological features such as personality as a risk factor [8]. The purpose of this nonrandomized quasi-experimental quantitative research study was to determine whether coronary artery spasm patients with a Type D personality were at a higher risk than patients who did not have a Type D personality to experience repeated episodes of coronary artery spasm requiring medical attention. Repeated episodes of coronary artery spasm was defined as two or more episodes during the patient's lifetime that required medical attention such as paramedics, fire rescue, visitation to hospital emergency room, outpatient cardiologist, primary care physician or hospitalization.

The following research question was most important:

Q1. Are repeated episodes of coronary artery spasm more prevalent among patient with Type D personality than non-Type D personality, controlling for age, gender, ethnicity, angina, stenosis, smoking, alcohol use, illicit drug, depression, and anxiety?

Hypotheses: It was hypothesized that the proportion of people experiencing repeat episodes of coronary artery spasm would be higher among patients who had a Type D personality compared to patients who did not have a Type D personality.

Ho: The probability of experiencing repeated episodes of coronary artery spasm among patients with a Type D personality would be equal to that of patients who did not have a Type D personality, controlling for age, gender, ethnicity, angina, stenosis, smoking, alcohol use, illicit drug, depression, and anxiety.

Ha: The probability of experiencing repeated episodes of coronary artery spasm among patients with a Type D personality would be greater than patients who did not have a Type D personality, controlling for age, gender, ethnicity, angina, stenosis, smoking, alcohol use, illicit drug, depression, and anxiety.

Method

Study design

This non-randomized quasi-experimental study utilized a total of 44 patients who had been diagnosed with coronary artery spasm. Coronary artery spasm was documented if an invasive procedure had been performed and the patient exhibited >50% reduction in artery lumen diameter and presented with angina and/or electrocardiographic ST-segment changes or if the patient had been clinically evaluated and a coronary artery spasm diagnosis was determined by the tending physician. Repeated episodes of coronary artery spasm was assessed if the patient experienced two or more events meeting the criteria above and the patient required medical attention such as paramedics, fire rescue, visitation to hospital emergency room, outpatient cardiologist, primary care physician or hospitalization. The sample size was determined via a Fisher's power and sample size analysis for two proportion with a power of 0.80, alpha level of 0.05, baseline proportion of 0.11 and comparison proportion of 0.44. The baseline proportion of 0.11 was determined based on the outcome of a 4-year follow-up study of coronary artery spasm patients, which found that 11% of patients experienced recurrent angina [39]. The comparison proportion of 0.44 was determined based on a study of cardiovascular disease and individuals who have a Type D personality which found that individuals who had a Type D personality had a four times higher risk of recurrent cardiac episodes compared to individuals who did not have a Type D personality [32].

Study participants

In keeping with the Framington Heart Study, an ongoing longitudinal cardiovascular disease study that has made significant contribution to the understanding of cardiovascular disease, the age range for this study was 30 to 75 years of age [41-45]. The study's inclusion criterion was cardiovascular disease patients 30 to 75 years of age that had been diagnosed with or were being treated for coronary artery spasm. Potential study participants were excluded if they were younger than 30 years of age or older than 75. Participants were recruited primarily through fee-based patient recruitment and referral services and direct fee-based advertisement in social media. Compensation was provided to study participants in the form of a \$10.00 electronic gift card.

Type D Personality

Type D personality was assessed using the Type D Scale–14 (DS14). Type D personality consist of two sub-traits; negative affectivity (NA) and social inhibition (SI). Study participants completed the Type D Scale-14 by responding to 14 questions on a 5-point Likert scale that ranges from 0 to 4, where 0 is false and 4 is true. Upon completion, the scores for questions 2, 4, 5, 7, 9, 12 and 13 were added to assess negative affectivity as were the scores for questions 1, 3, 6, 8, 19, 11 and 14 to assess social inhibition. Patients with a score of 10 or higher in negative affectivity and 10 or higher in social inhibition were qualified as Type D personality. Patients with a score of 9 or less in negative affectivity and 9 or less in social inhibition were determined to not have a Type D personality.

Type D personality can be assessed as a continuous or categorical variable. When assessed as a continuous variable the interaction between the two sub-traits are evaluated; negative affectivity x social inhibition. When assessed as a categorical variable the categories are based on high and/or low trait levels. We examined the prognostic value of Type D personality as both continuous and categorical variables as there are favorable arguments related to the clinical and theoretical importance

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for both approaches [46,47]. For the analysis of the categorical variable, the published cut-off score of 10 on the negative affectivity and social inhibition scales was used to construct two groups; a) high negative affectivity (NA > 10) and b) high social inhibition (SI > 10).

Measures

Patients meeting the inclusion criteria completed three separate instruments and one data collection form. The first instrument was the Clinically Useful Anxiety Outcome Scale, to assess anxiety symptoms. The second instrument was the Clinically Useful Depression Outcome Scale, to assess depression symptoms. The third instrument was the Type D Scale-14, to assess negative affectivity and social inhibition and determine Type D personality. The data collection form captured the patient's demographics, health behaviors, angiographic status, and medical status data. Anxiety and depression were assessed to verify existing literature which suggest that individuals who have a Type D personality have a higher risk of suffering from these disorders [16].

Anxiety: The Clinically Useful Anxiety Outcome Status (CUXOS) is an 20-item 5-point Likert scale assessment for anxiety symptoms. Individuals report how much anxiety symptoms bothered them during the prior week. The Likert scale ranges from 0 to 4, where 0 is not at all true and 4 is almost always true. A score of 0 to 10 indicates non-anxious, 11 to 20 is minimal anxiety, 21 to 30 is mild anxiety, 31 to 40 is moderate anxiety, and 41 and above is severe anxiety [48]. The Clinically Useful Anxiety Outcome Status baseline Cronbach's alpha was 0.95 for the entire scale and 0.90 and 0.93 for the psychic anxiety and somatic anxiety subscales respectively. The follow-up Cronbach's alpha was 0.95 for the entire scale and 0.94 and 0.91 for the psychic anxiety and somatic anxiety subscales respectively. The item-scale correlations were found to be significant with a mean of 0.67. The test-retest reliability was demonstrated at 0.90, 0.86 and 0.88 for the entire scale, psychic anxiety subscales respectively [48].

Depression: The Clinically Useful Depression Outcome Status (CUDOS) is an 18-item 5-point Likert scale assessment for depression symptoms. Individuals report how much depression symptoms bothered them during the prior week. The Likert scale ranges from 0 to 4, where 0 is not at all true and 4 is almost always true. A score of 0 to 10 indicates non-depressed, 11 to 20 is minimal depression, 21 to 30 is mild depression, 31 to 45 is moderate depression, and 46 and above is severe depression [39]. The Clinically Useful Depression Outcome Status baseline Cronbach's alpha was 0.90. The follow-up Cronbach's alpha was 0.90. The test-retest reliability was demonstrated at 0.92 and 0.95 at baseline and follow-up [49].

Type D Personality: The Type D Scale-14 is a 14-item, 5-point Likert scale standard assessment of negative affectivity and social inhibition and determination of Type D personality [24]. The Likert scale ranges from 0 to 4, where 0 is false and 4 is true, except for questions 1 and 3, where 4 is false and 0 is true. To determine Type D personality, the scores for questions 2, 4, 5, 7, 9, 12 and 13 were added to assess negative affectivity and the scores for questions 1, 3, 6, 8, 19, 11 and 14 were added to assess social inhibition. Patients were qualified as Type D personality if the negative affectivity score totaled 10 or higher and if the social inhibition score also totaled 10 or higher. Cronbach's alpha, a measure of internal consistency, demonstrated the reliability of the negative affectivity and the social inhibition subscales to be 0.88 and 0.86. The test-retest reliability was demonstrated at 0.72 and 0.82, with stability over a three-month period [24]. Internal consistency for the Type D Scale-14 was 0.87 for negative affectivity and 0.86 for social inhibition [24].

Other Variables of Interest: Age [35], gender [35], ethnicity [35], history of angina (severe chest pain) [42], history of stenosis (narrowing of blood vessel) [42], history of smoking [43], alcohol [31], and illicit drug use [44], which might influence repeated episodes of coronary artery spasm, were collected as covariates via the demographic, angiographic, and medical status and history data collection form. To characterize the patient's cardiac medical history and status, we also collected data regarding the patient's heart history and status; the number of years since the initial coronary artery spasm diagnosis, the number of lifetime coronary artery spasm events that required medical attention, the number of coronary artery spasms episodes for which medical attention was not sought, the number of years living with this medical condition, and the number of heart attacks experienced.

Statistical Analysis

Single regression models were generated to determine the importance of each individual predictor variable to the dependent variable; repeated episodes of coronary artery spasm. Multiple regression analysis was conducted to model the linear relationship between the dependent variable and the predictors variables; age, alcohol use, angina, anxiety, depression, ethnicity, gender, illicit drugs, smoking, and stenosis and to explain the association and importance between these variables. Hypotheses' testing was conducted to determine whether the proportions of patients experiencing repeated episodes of coronary artery spasm differed between those who had a Type D personality and those who did not have a Type D personality and to determine whether to reject the null hypothesis or fail to reject the null hypothesis. Correlation matrixes were generated to investigate the relationship between variables. Regression prediction was used to predict the potential number of coronary artery spasm episodes requiring medical attention over time. Logistic regression was used to assess the prognostic value of Type D personality's sub-traits; negative affectivity and social inhibition as categorical variables.

Results

Patient characteristics

A total of 44 patients with coronary artery spasm comprised this research study. The mean patient age was 45.59 years. More than half of patients were female. More than half of the patients had other comorbid disease or disorders, in addition to coronary artery spasm; in the form of heart failure, anxiety, and/or depression. The descriptive statistics and sample characteristics are summarized in Table 1.

Anxiety and Type D personality

More than two-thirds (88.64%) of the patients in this research study reported some level of anxiety. More than half (65.91%) of all participants manifested moderate to severe symptoms of anxiety. The results showed that 57.15% of females and 81.25% of males manifested moderate to severe symptoms of anxiety. The results also showed that 95.45% of the patients who had a Type D personality and 36.36% of the patients who did not have a Type D personality manifested moderate to severe symptoms of anxiety. The average anxiety score of the patients who had a Type D personality was 2.50 times higher than patients who did not have a Type D personality, thus this study suggests that individuals who have a Type D personality have a higher risk of suffering from anxiety disorder (Table 1).

Depression and Type D personality

Two-thirds (75.00%) of the patients in this research study reported

some level of depression. Less than half (40.91%) of all participants manifested moderate to severe symptoms of depression. The results showed that 25.00% of females and 68.75% of males manifested moderate to severe symptoms of depression. The results also showed that 77.27% of the patients who had a Type D personality and 4.55% of the patients who did not have a Type D personality manifested moderate to severe symptoms of depression. The average depression score of patients who had a Type D personality was 3.08 times higher than patients who did not have a Type D personality. Thus, this study suggests that individuals who have a Type D personality have a higher risk of suffering from depression disorder (Table 1).

Correlation Matrixes

A correlation matrix was completed for patients who did not have a Type D personality to determine the degree of statistical relationship between pairs of variables. Table 2 showed that in relationship to the dependent variable; repeated episodes of coronary artery spasm, alcohol use had the most significant relationship with a moderate correlation that was statistically significant (r=.422, p=.050). The data also showed that age, gender, and smoking had moderate correlation, but these were not statistically significant; r=-.339, p=.124; r=-.327,

	Total	Non-Type D	Type D	
	(n)	(n)	(n)	
	44	22	22	
Age				
30 - 40	16	4	12	
41 - 50	12	5	7	
51 - 60	14	11	3	
61 - 70	0	0	0	
71 - 75	2	1	1	
Gender				
Male	16	5	11	
Female	28	17	11	
Ethnicity				
African-American	0	0	0	
Asian	3	1	2	
Caucasian	31	15	16	
Hispanic	7	5	2	
Native American	1	0	1	
Other	2	1	1	
Anxiety Status (per CUXOS)				
Non-anxious	5	5	0	
Minimal	6	6	0	
Mild	4	3	1	
Moderate	9	6	3	
Severe	20	2	18	
Depression Status (per CUDOS)				
Non-depressed	10	9	1	
Minimal	5	5	0	
Mild	11	7	4	
Moderate	1	1	0	
Severe	17	0	17	
Mean Scores and Standard Deviations of Measures				
Clinically Useful Anxiety Outcome Status		M= 22.41, SD= 13.08	M= 56.06, SD= 11.94	
Clinically Useful Depression Outcome Status		M= 14.82, SD= 9.71	M= 45.64, SD= 13.45	

Table 1: Descriptive statistics and demographic characteristics of coronary artery spasm patients and mean scores and standard deviations of CUXOS and CUDOS measures.

p=.137; and r=.304, p=.168 respectively. Angina, ethnicity, illicit drug use, and stenosis did not have a correlation to the dependent variable.

A correlation matrix was also completed for patients who had a Type D personality to determine the degree of statistical relationship between pairs of variables. Table 3 showed that in relationship to the dependent variable; repeated episodes of coronary artery spasm, smoking had a moderate correlation that approximated statistically significance (r=-.434, p=.056). The data also showed that illicit drug use had a moderate correlation as well, but was not statistically significant; r=-.311, p=.182. Age, angina, gender, ethnicity, alcohol, and stenosis did not have a correlation to the dependent variable.

	CAD patients	CAD patients with						
	without Type D personality n= 22	Type D personality n= 22	p-value					
Demographics								
Age	50	41.18	0.005					
Male	5	11						
Female	17	11						
Comorbid Disease/Disorders								
Anxiety (CUXOS)	22.41	56.6	0					
Depression (CUDOS)	14.82	45.64	0.001					
Heart failure	0.82	2.27	0.001					
Type D Personality Sub-Traits								
Negative Affectivity	5.55	19.86	0					
Social Inhibition	5.18	18.23	0					
Coronary Artery Spasm								
Repeated episodes requiring								
medical attention	14	20	0.022					

Type D Personality as a Predictor of Coronary Artery Spasm

Hypothesis test

A 2 proportions test was conducted to determine whether the proportions of patients experiencing repeated episodes of coronary artery spasm differed between patients who had a Type D personality and patients who did not have a Type D personality. The 2 proportions test uses normal approximation to compute the hypotheses test, the confidence interval, and the p-value and is based on Z-statistics. The hypothesis was supported, the effect proved to be statistically significant, d=.27, p =.022, 95% CI [.0385548, .506900], z=2.28. Thus, the null hypothesis was rejected and the alternative hypothesis was accepted; the probability of experiencing repeated episodes of coronary artery spasm was greater among patients who had a Type D personality compared to patients who did not have a Type D personality. The conclusion is that the mean value of coronary artery spasms for patients who had a Type D personality was higher than that of patients who did not have a Type D personality. In other words, coronary artery spasm is more prevalent among patients who had a Type D personality than patients who did not have a Type D personality (Table 4).

Correlation matrixes

Correlation matrixes were separately completed for the Type D sub-traits negative affectivity and social inhibition to determine the degree of statistical relationship between these and the dependent variable, repeated episodes of coronary artery spasm. For patients who did not have a Type D personality, there was no correlation or statistical significance between negative affectivity and repeated episodes of coronary artery spasm (r=-.002, p=.994) and a moderate correlation but not statistically significant with social inhibition (r=.368, p=.092).

		Age	Gender	Ethnicity	Alcohol Use	Smoking	Illicit Drugs	Angina	Stenosis	Repeated Episodes CAS
Age	Pearson's Corelation	1	0.369	0.347	-0.242	0.066	-0.189	-0.394	0.387	-0.338
	Significance	-	0.091	0.113	0.277	0.772	0.399	0.07	0.075	0.124
Gender	Pearson's Corelation	0.369	1	0.058	-0.385	-0.162	0.101	-0.375	0.191	-0.327
	Significance	0.091	-	0.797	0.077	0.472	0.565	0.085	0.394	0.137
Ethnicity	Pearson's Corelation	0.347	0.058	1	-0.193	-0.125	-0.166	-0.289	-0.15	-0.286
	Significance	0.113	0.797	-	0.39	0.58	0.461	0.192	0.504	0.197
Alcohol Use	Pearson's Corelation	-0.242	0.385	-0.193	1	0.651	-0.052	-0.164	-0.318	0.422
	Significance	0.277	0.077	0.39	-	0.001	0.818	0.467	0.15	0.05
Smoking	Pearson's Corelation	0.066	-0.162	-0.125	0.651	1	-0.119	-0.482	-0.088	0.304
Shloking	Significance	0.772	0.472	0.58	0.001	-	0.599	0.023	0.698	0.168
Illicit Drugs	Pearson's Corelation	-0.189	0.101	-0.166	-0.052	-0.119	1	0.092	-0.117	0.089
_	Significance	0.399	0.565	0.461	0.818	0.599	-	0.685	0.605	0.693
Angina	Pearson's Corelation	-0.394	-0.375	-0.289	-0.164	-0.482	0.092	1	0	0.165
	Significance	0.07	0.085	0.192	0.467	0.023	0.685	-	1	0.463
Stenosis	Pearson's Corelation	0.387	0.191	-0.15	-0.318	-0.088	-0.117	0	1	-0.131
	Significance	0.075	0.394	0.504	0.15	0.698	0.605	1	-	0.561
Repeated Episodes	Pearson's Corelation	-0.338	-0.327	-0.286	0.422	0.304	0.089	0.165	-0.131	1
CAS	Significance	0.124	0.137	0.197	0.05	0.168	0.693	0.463	0.561	-

 Table 3: Correlation matrix of predictive variables for Non- Type D.

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		Age	Gender	Ethnicity	Alcohol Use	Smoking	Illicit Drugs	Angina	Stenosis	Repeated Episodes CAS
A ===	Pearson's Corelation	1	0.001	-0.088	0.618	0.215	0.241	0.156	0.062	0.186
Age	Significance	-	0.996	0.712	0.004	0.363	0.306	0.511	0.796	0.432
0	Pearson's Corelation	0.001	1	-0.036	0.373	0.199	0.358	-0.142	0	0.113
Gender	Significance	0.996	-	0.881	0.105	0.4	0.121	0.55	1	0.637
Félorialita	Pearson's Corelation	-0.088	-0.036	1	-0.104	0.392	0.082	-0.336	-0.094	-0.284
Ethnicity	Significance	0.712	0.881	-	0.664	0.087	0.732	0.148	0.694	0.225
Alcohol Use	Pearson's Corelation Significance	0.618	0.373	-0.104	1	0.24	0.605	-0.154	0.345	0.205
		0.004	0.105	0.664	-	0.307	0.005	0.516	0.136	0.386
Smoking	Pearson's Corelation Significance	0.215	0.199	0.392	0.24	1	0.115	-0.249	-0.348	-0.434
		0.363	0.4	0.087	0.307	-	0.63	0.289	0.132	0.056
Illicit Drugs	Pearson's Corelation Significance	0.241	0.358	0.082	0.605	0.115	1	0	0.165	0.311
		0.306	0.121	0.732	0.005	0.63	-	1	0.487	0.182
Angina	Pearson's Corelation Significance	0.156	-0.142	-0.336	-0.154	-0.249	0	1	-0.447	0.128
		0.511	0.55	0.148	0.516	0.289	1	-	0.048	0.589
Oteneraia	Pearson's Corelation Significance	0.062	0	-0.094	0.345	-0.348	0.165	-0.447	1	0.144
Stenosis		0.796	1	0.694	0.136	0.132	0.487	0.048	-	0.546
D	Pearson's Corelation Significance	0.186	0.113	-0.284	0.205	-0.434	0.311	0.128	0.144	1
Repeated Episodes CAS		0.432	0.637	0.225	0.386	0.056	0.182	0.589	0.546	-

Table 4: Correlation matrix of predictive variables for Type D.

For patients who had a Type D personality, there was a moderate correlation of statistical significance for both negative affectivity and social inhibition and the dependent variable, repeated episodes of coronary artery spasm (r=-.455, p=.044; r=.483, p=.031 respectively).

Regression models

Single regression models were generated to determine the importance of each individual predictor variable to the dependent variable; repeated episodes of coronary artery spasm. For patients who did not have a Type D personality, none of the variables (negative affectivity, social inhibition, age, gender, ethnicity, alcohol use, smoking, illicit drug use, angina, and stenosis) significantly predicted repeated episodes of coronary artery spasm. For patients who had a Type D personality, two of the variables significantly predicted repeated episodes of coronary artery spasm; negative affectivity (F(1,18) = 4.69, p = .044, $R^2 = 20.67\%$) and social inhibition (F(1,18) = 5.46, p = .031, $R^2 = 23.297\%$).

Multiple regression analysis was conducted to determine the importance of the predictor variables. Due to the small sample size, the multiple regression models were adjusted to only accommodate some possible confounders and computed using Bonferroni corrections and a critical alpha of 0.001. This was calculated by dividing the original alpha of 0.05 by 45 possible combinations. For patients who did not have a Type D personality, the multiple regression model was adjusted for gender, alcohol use, smoking, and illicit drug use. For patients who had a Type D personality, the multiple regression model was adjusted for gender, smoking, and illicit drug use. Gender, smoking, and illicit drug use were highlighted as important risk factor for coronary artery spasm in a recent peer-reviewed scientific statement emitted by the American Heart Association [50]. The multiple regression for patients who did not have a Type D personality included alcohol because the correlation matrix determined that alcohol use had the most significant relationship with coronary artery spasm rate with a moderate correlation that was statistically significant (r=.422, p=.050). For patients who did not have a Type D personality, alcohol use (F(1,21) = .840, p = .371), gender (F(1,21) = .870, p = .365), illicit drug use (F(1,21) = .410, p = .531), nor smoking (F(1,21) = .140, p = .717) were significant predictors of the coronary artery spasm rate. For patients that had a Type D personality, gender (F(1,19) = .160, p = .692) nor illicit drug use (F(1,19) = 2.320, p = .147) were significant predictors of coronary artery spasm rate, but smoking (F(1,19) = 5.47, p = .033) was a significant predictor of the coronary artery spasm rate.

Logistic regression models were generated for Type D personality's sub-traits, negative affectivity and social inhibition, which were analyzed as categorical variables, to examine its prognostic value and determine if these independently predicted repeated episodes of coronary artery spasm. The logistic regression model for high negative affectivity (Y' = -1.95 + 0.171 High NA) did not significantly predict repeated episodes of coronary artery spasm (p = 0.071, R² = 10.557%, n = 27). The logistic regression model for high social inhibition (P(2) = exp(-3.34 + 0.260 High SI)/(1 + exp(-3.34 + 0.260 High SI) significantly predicted repeated episodes of coronary artery spasm (p = 0.028, R² = 17.95%, n = 23).

Discussion

Main findings

Coronary artery spasm is a serious medical condition not a passive inconvenience. It is a known precipitant of recurrent chest pain and is associated with myocardial infarction and sudden death. Its diagnosis, however, is difficult due to the transience of the symptoms and its pathogenesis is multifactorial [51]. While provocation testing has been effective at definitive diagnosis, it has been identified as a predictor of major adverse cardiac events [51]. Doctors are performing less provocative testing due to insurance and reimbursement pressures [40]. Coronary artery spasm remains an under researched area of study. Important findings surfaced from this study.

The major finding of this study was that patients who had a Type D personality were at a higher risk than patients who did not have a Type D personality to suffer from and experience recurrence of coronary artery spasm requiring medical attention. This finding suggests that Type D personality is a risk factor for coronary artery spasm. To the best of our knowledge, this is the first study that documents the association between Type D personality and coronary artery spasm. This is a key contribution to the body of knowledge because it augments and increases the knowledge and understanding of the role that Type

D personality plays in cardiovascular health and its association and predictability significance for repeated episodes of coronary artery spasm.

Data analysis revealed several additional important findings; (1) there was an association between anxiety and depression and Type D personality. This association is characteristic of Type D personality and largely attributed to conscious suppression of emotion [50]; (2) there was a significant correlation between negative affectivity and social inhibition (traits of Type D personality) and repeated episodes of coronary artery spasm; (3) negative affectivity and social inhibition were predictors of coronary artery spasm episodes; (4) high social inhibition was a predictor of repeated episodes of coronary artery spasm but high negative affectivity was not; and (5) smoking was a predictor of coronary artery spasm among patients who had a Type D personality.

The implication of these findings is that individuals who have a Type D personality and suffer from coronary artery spasm will likely become recurrent consumers of mental health and cardiovascular healthcare services to treat anxiety, depression, emotional distress, coronary artery spasm, and/or myocardial dysfunction. Insurance companies, cardiologists, and primary care physicians must be conversant with Type D personality research and develop adjunctive therapies and diagnosis models. Without these, the cost of healthcare is likely to significantly increase. As the cost of treatment of chronic diseases represents a significant burden to the government and private healthcare insurance providers alike [52], it is important that healthcare professionals and medical decision-makers promptly identify Type D personality patients.

Research has categorically linked Type D personality to poor outcomes in cardiovascular health [12], inadequate response to cardiac treatment [15], and higher rates of mortality and nonfatal myocardial infarction [53]. Cardiologists, primary care physicians, and other specialized medical practices should be trained at different levels of their formal professional development. Coursework in graduate schools, specialized skill set development, and clinical internships should devote time and effort to educating emerging physicians and other healthcare professionals of the link and the role that Type D personality plays as a risk factor for coronary artery spasm as founded in this study.

Biological Pathways that Might Explain the Association between Type D Personality and Increased Vulnerability to Coronary Artery Spasm

Several recent studies have shown that Type D personality is associated with increased levels of endothelial dysfunction and macrophage activity [54,55]. Evidence suggests that Type D personality may contribute to functional coronary abnormalities through other biological pathways such as higher macrophage superoxide anion production [55] and endothelial dysfunction [55]. These pathophysiological mechanisms may contribute to the increased risk of coronary artery spasm observed in this study and might explain the association between Type D personality and increased vulnerability to coronary artery spasm.

Endothelial dysfunction is a known biological response to cardiovascular risk factors [56]. Vascular endothelium is vital for blood flow regulation, tissue wound healing, vascular homeostasis, molecule traffic between blood and tissues, and anti-coagulation [57]. Endothelial dysfunction results in decreased blood flow to tissues, diminished production of nitric oxide, and leads to poor vascular reactivity, which is the vascular system's ability to quickly deliver blood to organs when needed [56]. Biological inflammation is a known cause of endothelial dysfunction [58]. Studies have shown that Type D personality is significantly linked to increased inflammation biomarkers and reduced endothelial function [54,55]. This might explain the functional coronary abnormality that occurs with a coronary artery spasm and that results in the constriction of the arteries, reduced blood flow, and the starvation of oxygenated blood to the heart muscle. Endothelial dysfunction is a candidate pathophysiological mechanism to explain the association between Type D personality and increased vulnerability to coronary artery spasm.

Macrophages are immune cells that form in response to infection, invading cells, or dead cells and execute a phagocytotic function that consist of ingesting or engulfing other cells or particles [59]. Bacterial cells are the strongest influence for the activation of macrophages superoxide anion. Superoxide anion is a chemical compound that is biologically toxic and is deployed by the body's immune system to fight off invading microorganisms [59-61]. Evidence suggests that superoxide anion plays a central role in the development and progression of atherosclerosis which is characterized by the formation of fatty material plague that adheres to the inner walls of blood vessels [55].

A recent study produced evidence that coronary artery disease patients who had a Type D personality produced higher levels of macrophages superxide anion in comparison to patients who did not have a Type D personality and suggested that higher levels of macrophages superxide anion play a significant role in the poor prognosis of coronary artery disease patients [55]. This study might also explain the functional coronary abnormality that occurs with a coronary artery spasm that results in the constriction of the arteries, reduced blood flow, and the starvation of oxygenated blood to the heart muscle. Higher level of macrophages activity is a candidate pathophysiological mechanism to explain the association between Type D personality and increased vulnerability to coronary artery spasm.

Study Limitations

A limitation of this study is its small sample size; therefore, we could only accommodate some possible confounders that might impact or have an effect on repeated episodes of coronary artery spasm in the multiple regression models. Future studies should include a larger sample size to allow the complex dynamics between Type D personality and repeated episodes of coronary artery spasm to be better elucidated and results verified. Therefore, our findings should be regarded as exploratory and the need for replication highlighted.

An additional limitation of this study was the lack of representation from the African-American ethnic group. While this study was made available to all ethnic groups, African-American was the only ethnic group not represented in the study. No African-American patient volunteered to participate in the study. This represents a limitation of the study because African-Americans are at greatest risk of cardiovascular disease [36]. African-Americans are an understudied ethnicity group in biomedical and behavioral research in general, as well as cardiovascular disease however; they have the highest and most disproportional rate of cardiovascular disease-related morbidity and mortality of any race or ethnicity [37]. The heart failure rate among African-Americans is 20 times higher than Caucasians [36]. Future study should purposely seek out African-American coronary artery spasm patients for inclusion. The blind nature of this study limited the ability to seek out this underrepresented ethnic group.

Conclusion

This study shows that patients that experience coronary artery spasm and have a Type D personality are at higher risk of suffering repeated episodes that require medical attention. Type D personality was associated with and is a predictor of coronary artery spasm. This study suggests that Type D personality is a risk factor for the incidence and recurrence of coronary artery spasm requiring medical attention. The strength of this study is that it is the first study to explore and assess the relationship between Type D personality, its sub-traits, and coronary artery spasm by use of an objective measure to determine repeated episodes of coronary artery spasm. As the cost of treating coronary heart diseases represents a significant financial burden to the government as well as private healthcare insurance providers, the findings of this study may help in the development of adjunctive therapies and diagnosis models. To this end, an enhanced understanding of the linkage between Type D personality and coronary artery spasm is critical among cardiologists, other cardiovascular health professionals, and insurance providers.

Disclosures

None

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