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Original Article

# Impact of type D personality on clinical outcomes in Asian patients with stable coronary artery disease

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**KEYWORDS**
Type D personality;
Coronary artery disease

*Background:* Some personality types are associated with cardiovascular (CV) diseases and may be related to clinical outcomes in coronary artery disease (CAD). This study investigates the association between type D personality and clinical outcomes in stable CAD patients in an Asian cohort.
*Methods:* Stable CAD patients were enrolled and prospectively followed up for at least 1 year in Taiwan. The inclusion criteria were at least one successful percutaneous coronary intervention (PCI) and stable medical treatment for at least 1 month before enrollment. Vulnerability to psychological distress was measured by the Type D Personality Scale (DS14) after enrollment. The end point was the occurrence of total CV events. Cox regression models of CV events were used to investigate the role of type D personality in clinical outcomes.
*Results:* The study included 777 patients, among which 122 (15.77%) had type D personality. Forty-two CV events were identified: 3 cardiac deaths, 5 nonfatal myocardial infarctions, 1 stroke, 4 congestive heart failures (CHF), 6 peripheral arterial occlusive disorder cases, and 23 readmissions for angina/revascularization treatment. Patients with type D personality had significantly higher incidence of future CV events (9.84% vs. 4.58%, $p = 0.018\%$) and admission for angina/revascularization (5.74% vs. 2.44%, $p = 0.049$). Patients with subsequent CV events were more likely to have type D personality **(28.57% vs. 14.97%, p=0.018).** After proportional Cox regression analysis, type D personality remained an independent predictor of future CV events (HR: 3.21, 95% CI: 1.06−9.69). In subgroup analyses, type D personality was especially associated with higher risk of total CV events among females, the elderly, hypertension patients, diabetes patients, and non-smokers.
*Conclusion:* Type D personality was an independent predictor of CV outcomes in an Asian cohort of stable CAD patients. This personality type may be identified in risk stratification for secondary prevention after PCI.


## Introduction

Coronary artery disease (CAD) is the leading cause of death worldwide and is associated with a considerable risk of mortality and morbidity. Great efforts are made to prevent the recurrence of the disease, including lifestyle modification and pharmacological therapy, but future adverse events continue to increase, especially in high-risk CAD patients. Such events include acute coronary syndrome, stroke, sudden death, or hospitalization for intervention procedures or heart failure. In addition to traditional risk factors, psychological stress has been widely investigated for possible connections with cardiovascular (CV) diseases. Recent evidence suggests potential connections between CV disease and personality traits, especially type D personality.[1−7]

Type D or "distressed" personality is a combination of two personality traits: negative affectivity (NA, the tendency to experience negative emotions) and social inhibition (SI, the tendency to inhibit the expression of emotions).[1] People with type D personality may suffer from particular psychological stress, which has been reported to be associated with some CV diseases, including CAD,[2,3] congestive heart failure,[4,5] peripheral artery disease,[6] and cardiac arrhythmia.[7] It has been reported that type D personality is related to adverse events in cardiac patients[2−7] and is considered as a psychosocial risk marker by the European Heart Society[8,9] for patients with cardiovascular disease. However, some studies show no effect on patients who have undergone percutaneous coronary intervention (PCI)[10] and on mortality.[11]

A meta-analysis of prospective cohort studies showed that type D predicted a 2-fold increased risk of cardiac events, but the association of type D and the prognosis in cardiac patients is different between types of cardiac diseases.[12] Few studies have investigated the prognostic value of type D in Asian populations, especially among patients who have undergone PCI and have already received aggressive medical treatments and coronary interventions. Accordingly, this study was conducted to investigate if type D personality could be associated with the risk of future CV events in Asian CAD patients who were previously treated with a successful PCI.

## Methods

### Study population

A series of stable CAD patients was evaluated in nine different medical centers located in the northern, central, southern, or eastern areas in Taiwan since from September 2012 to September 2014. Patients were initially evaluated if they had a history of significant CAD documented in a coronary angiogram, a history of myocardial infarction evidenced by electrocardiogram (ECG) or hospitalization, or a history of angina with ischemic ECG changes or a positive response to stress tests. Patients were enrolled only if (1) they had at least once previously received a successful PCI with either coronary stenting or balloon angioplasty, and (2) they had been stable on medical treatment for at least 1 month before enrollment.

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Biochemical markers and lipid profiles were checked in this study. All participants had undergone PCI, and some patients were enrolled after an episode of acute coronary syndrome including acute myocardial infarction (MI) and unstable angina. To avoid the influence of acute stress of acute coronary events, we enrolled only CAD patients who had been stable on medical treatment for at least 1 month before enrollment. Similar enrollment criteria were reported in previous work.[13]

Patients were excluded if (1) they had been hospitalized for unstable angina, acute coronary syndrome, acute MI, acute cerebrovascular events, or other acute cardiovascular events within 3 months before enrollment, (2) they planned to receive further coronary revascularization or interventional procedures for other CV diseases in the following year, (3) they had significant malignancy or tumor diseases requiring advanced medical or surgical therapy in the following year, (4) they had other major systemic diseases requiring hospitalization or a planned operation in the following year, or (5) they were unable or unwilling to be followed up on in the following year. This study was approved by the institutional research board ethics committees in each hospital. All patients gave written informed consent before participating in the study.

### Identification and diagnosis of type D personality

After enrollment, all patients were asked to complete the Type D Scale for Taiwan (DS14-T). This version was translated from the original DS14 scale and validated for the Taiwanese population.[14] The reliability of the type D assessment in Taiwan was good, with Cronbach's $\alpha$ for negative affectivity and social inhibition equal to 0.86 and 0.79, respectively.[14] This version has adequate construct validity and can be considered equivalent to the English version.[14]

In short, this instrument measures NA (e.g., "I often make a fuss about unimportant things," and, "I have a gloomy view of things") and SI (e.g., "I make contact easily when I meet people," and, "I find it hard to start a conversation"). The scale has seven five-point items that are rated on a Likert scale ranging from 0 (false) to 4 (true) for each subscale. It is regarded as the current standard for identifying type D patterns.[15] Using a standardized cut-off score $\geq$10, patients scoring high on both subscales were classified as having a type D personality.[14]

### Baseline data collection

Specially trained study nurses and qualified cardiologists collected all prospective data whenever feasible. Baseline characteristics were also collected, including risk factors such as history of hypertension, diabetes, smoking habits, and medication history. In addition, biochemical profiles were recorded, including blood glucose, lipid profile, and kidney function.

### Clinical follow-up for adverse cardiovascular events

Each patient with initially stable conditions under medical treatment was checked regularly in a single hospital clinic at 3-month intervals for at least 1 year after enrollment. The study endpoint is the time to CV events and included CV death, nonfatal acute MI, nonfatal stroke, unplanned revascularization procedures, hospitalization for refractory or unstable angina, and hospitalization for other causes including stroke, transient ischemic attack, or peripheral arterial occlusive disorder. This information was recorded during each follow-up.

MI was confirmed by ischemic symptoms presenting with elevated serum cardiac enzyme levels or characteristic ECG changes. Coronary revascularization procedures with either a PCI or coronary artery bypass grafting (CABG) were confirmed by a medical record review. Stroke was defined as a new neurologic deficit lasting for at least 24 h with definite image evidence of a cerebrovascular accident by either magnetic resonance imaging (MRI) or by computed tomography (CT) scan. The protocol for a follow-up CV event was similar to that reported in previous works.[13,16]

### Statistics

Statistical analysis was performed using SPSS (Version 17.0; SPSS Inc., Chicago, IL, USA). All data are expressed as the frequency (percentage) or mean $\pm$ SD. Parametric continuous data among the different groups of patients were compared using unpaired student's t-tests. Categorical data among the different groups were compared using the chi-squared test and Yates' correction or Fisher's exact test as appropriate. A survival analysis was done using Kaplan–Meier analysis with significance based on the log-rank test. Univariate regression analysis was carried out using Cox proportional hazards regression analysis.

To determine the independent predictor values, adjusted risk-factor estimates were obtained using the Cox proportional-hazards regression model. All the variables presented in univariate models were evaluated as possible predictors of clinical events, and those variables that distribute differently ($p < 0.05$) between Event (+) and Event (−) in the multivariate Cox models. Statistical significance was inferred with a two-sided p value of $<$0.05.

## Results

### Patient characteristics

A total of 777 stable CAD patients with a previous successful PCI were enrolled and completed one year of clinical follow-up. Type D personality was identified in 122 patients (15.77%). Table 1 shows the baseline characteristics of these 777 CAD patients. There was no difference in age between the patients with and without type D personality (62.28 $\pm$ 12.47 vs. 62.03 $\pm$ 10.50 years, $p = 0.837$). There were also no significant differences between the two groups in terms of gender, hypertension, diabetes, smoking habits, baseline blood pressure, body mass index (BMI), serum cholesterol, triglycerides, LDL cholesterol, creatinine levels, and medications for CV diseases.

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**Table 1** Baseline characteristics of study population.

| | Type D (−) N = 655 | Type D (+) N = 122 | *P* |
|---|---|---|---|
| Age | 62.03 ± 10.50 | 62.28 ± 12.47 | 0.837 |
| Male, n (%) | 552 (84.27%) | 98 (80.33%) | 0.279 |
| BMI, Kg/m$^2$ | 26.88 ± 4.77 | 26.99 ± 7.18 | 0.866 |
| Hypertension, n (%) | 392 (59.85%) | 75 (61.48%) | 0.736 |
| DM, n (%) | 229 (34.96%) | 52 (42.62%) | 0.106 |
| Smoking, n (%) | 356 (54.35%) | 55 (45.08%) | 0.060 |
| Waist, cm | 94.98 ± 10.25 | 94.58 ± 9.54 | 0.756 |
| Buttock, cm | 101.17 ± 8.42 | 101.87 ± 8.84 | 0.517 |
| Waist/buttock ratio | 0.94 ± 0.08 | 0.93 ± 0.05 | 0.161 |
| Systolic BP, mmHg | 130.90 ± 16.48 | 133.27 ± 19.35 | 0.212 |
| Diastolic BP, mmHg | 75.27 ± 11.52 | 75.25 ± 11.97 | 0.991 |
| LVEF, % | 59.98 ± 13.20 | 61.21 ± 11.94 | 0.594 |
| Glucose, mg/dL | 123.82 ± 47.80 | 133.30 ± 62.48 | 0.114 |
| Cholesterol, mg/dL | 164.34 ± 37.89 | 165.66 ± 34.38 | 0.731 |
| LDL-C, mg/dL | 98.66 ± 31.57 | 102.82 ± 28.86 | 0.200 |
| HDL-C, mg/dL | 42.46 ± 11.14 | 41.95 ± 11.40 | 0.659 |
| Triglyceride, mg/dL | 136.61 ± 85.16 | 140.11 ± 100.40 | 0.722 |
| TC/HDL-C ratio | 4.08 ± 1.33 | 4.19 ± 1.33 | 0.438 |
| eGFR | 79.13 ± 34.72 | 81.62 ± 35.49 | 0.469 |
| Total stent, n | 1.43 ± 0.75 | 1.46 ± 0.86 | 0.756 |
| Average length of stent, mm | 22.21 ± 6.44 | 23.11 ± 6.56 | 0.267 |
| Average diameter of stent, mm | 3.02 ± 0.54 | 2.92 ± 0.51 | 0.135 |
| Antiplatelet, n (%) | 605 (92.37%) | 112 (91.80%) | 0.831 |
| Statin, n (%) | 486 (74.20%) | 94 (77.05%) | 0.506 |
| ACEI/ARB, n (%) | 393 (60.00%) | 73 (59.84%) | 0.973 |
| BB, n (%) | 405 (61.83%) | 81 (66.39%) | 0.339 |
| CCB, n (%) | 222 (33.89%) | 38 (31.15%) | 0.555 |
| Diuretics, n (%) | 79 (12.06%) | 16 (13.11%) | 0.744 |
| Total CV events, n (%) | 30 (4.58%) | 12 (9.84%) | 0.018 |
| Cardiac death, n (%) | 2 (0.31%) | 1 (0.82%) | 0.400 |
| Myocardial infarction, n (%) | 5 (0.76%) | (0.00%) | 0.333 |
| Stroke, n (%) | 1 (0.15%) | (0.00%) | 0.666 |
| Hospitalization for angina/re-vascularization, n (%) | 16 (2.44%) | 7 (5.74%) | 0.049 |

Values Data are n (%) or mean ± SD, BMI indicates body mass index; DM, diabetes; LVEF: left ventricular ejection fraction; LDL-C: low density lipoprotein cholesterol; HDL-C, HDL: high density lipoprotein-cholesterol; eGFR, estimated glomerular fraction rate; ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; BB, beta-blocker; CCB, calcium channel blocker.

## Adverse cardiovascular events during the follow-up period

All patients were monitored regularly in the hospital clinic for at least 1 year for adverse CV events. Among the 777 CAD patients enrolled, a total of 42 total CV events were identified, including 3 cardiac deaths, 5 nonfatal MIs, 1 stroke, 4 congestive heart failures (CHF), 6 cases of peripheral arterial occlusive disorder (PAOD), and 23 readmissions for angina or revascularization treatment. Patients with type D personality had a significantly higher incidence of future CV events (9.84% vs. 4.58%, p = 0.018%) and admission for angina/revascularization (5.74% vs. 2.44%, p = 0.049).

The baseline characteristics of the patients with and without total adverse CV events are shown in Table 2. The patients with subsequent CV events were more likely to have type D personality **(28.57% vs. 14.97%, p=0.018)** and type 2 diabetes **(59.52% vs. 34.83%, p=0.001).** In addition, the patients with CV events had larger buttock circumstances (103.69 ± 4.54 cm vs. 101.17 ± 8.59 cm, p = 0.025), higher serum glucose levels (147.79 ± 65.30 vs. 124.03 ± 49.23, p = 0.025), higher serum total cholesterol/HDL-cholesterol ratios (4.66 ± 1.54 vs. 4.07 ± 1.31, p = 0.01), and lower serum HDL levels (37.41 ± 11.50 mg/dL vs. 42.64 ± 11.11 mg/dL, p = 0.006). In addition, patients with events had worse renal function (eGFR: 65.02 ± 41.47 vs. 80.35 ± 34.26, p = 0.006), smaller stent diameter (2.86 ± 0.27 vs. 3.02 ± 0.55 mm, p = 0.008), less medication with angiotensin-converting enzyme (ACE) inhibitors or angiotensin II receptor blockers (ARBs) (45.2% vs. 60.82%, p = 0.045), and less statin use (59.52% vs. 75.51%, p = 0.021).

Fig. 1 shows the results of the log-rank test and Kaplan–Meier survival analysis. The cumulative incidence of future total CV events was significantly higher in CAD

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**Table 2** Basal characteristics of CAD patients with or without future cardiovascular events.

| | Event (−) n = 735 | Event (+) n = 42 | P |
|---|---|---|---|
| Age | 61.91 ± 10.68 | 64.91 ± 12.97 | 0.081 |
| Male, n (%) | 619 (84.22%) | 31 (73.81%) | 0.076 |
| BMI, Kg/m$^2$ | 26.93 ± 5.30 | 26.30 ± 3.42 | 0.272 |
| Hypertension, n (%) | 442 (60.14%) | 25 (59.52%) | 0.937 |
| DM, n (%) | 256 (34.83%) | 25 (59.52%) | 0.001 |
| Smoking, n (%) | 385 (52.38%) | 26 (61.90%) | 0.229 |
| Type D personality, n (%) | 110 (14.97%) | 12 (28.57%) | 0.018 |
| Waist, cm | 94.87 ± 10.31 | 96.19 ± 4.82 | 0.259 |
| Buttock, cm | 101.17 ± 8.59 | 103.69 ± 4.54 | 0.025 |
| Waist/buttock ratio | 0.94 ± 0.08 | 0.93 ± 0.05 | 0.418 |
| Systolic BP, mmHg | 131.10 ± 16.41 | 134.26 ± 24.73 | 0.417 |
| Diastolic BP, mmHg | 75.42 ± 11.36 | 72.64 ± 14.83 | 0.240 |
| LVEF, % | 60.09 ± 13.02 | 61.72 ± 14.04 | 0.713 |
| Glucose, mg/dL | 124.03 ± 49.23 | 147.79 ± 65.30 | 0.025 |
| Total Cholesterol, mg/dL | 164.48 ± 37.11 | 165.65 ± 42.14 | 0.854 |
| LDL-C, mg/dL | 99.26 ± 31.24 | 99.86 ± 30.63 | 0.911 |
| HDL-C, mg/dL | 42.64 ± 11.11 | 37.41 ± 11.50 | 0.006 |
| Triglyceride, mg/dL | 135.99 ± 85.87 | 159.08 ± 115.63 | 0.232 |
| TC/HDL-C ratio | 4.07 ± 1.31 | 4.66 ± 1.54 | 0.010 |
| eGFR | 80.35 ± 34.26 | 65.02 ± 41.47 | 0.006 |
| Total stent, n | 1.42 ± 0.76 | 1.63 ± 0.76 | 0.146 |
| Average length of stent, mm | 22.28 ± 6.52 | 23.30 ± 5.56 | 0.413 |
| Average diameters of stent,mm | 3.02 ± 0.55 | 2.86 ± 0.27 | 0.008 |
| Antiplatelet, n (%) | 678 (92.24%) | 39 (92.86%) | 0.885 |
| Statin, n (%) | 555 (75.51%) | 25 (59.52%) | 0.021 |
| ACEI/ARB, n (%) | 447 (60.82%) | 19 (45.24%) | 0.045 |
| BB, n (%) | 463 (62.99%) | 23 (54.76%) | 0.284 |
| CCB, n (%) | 242 (32.93%) | 18 (42.86%) | 0.185 |
| Diuretics, n (%) | 89 (12.11%) | 6 (14.29%) | 0.675 |

Values Data are n (%) or mean ± SD, BMI indicates body mass index; DM, diabetes; LVEF: left ventricular ejection fraction; LDL-C: low density lipoprotein cholesterol; HDL-C, high density lipoprotein-cholesterol; eGFR, estimated glomerular fraction rate; WBC, white blood cell; ACE: angiotensin-converting enzyme; ARB: angiotensin receptor blocker; BB, beta-blocker; CCB, calcium channel blocker.

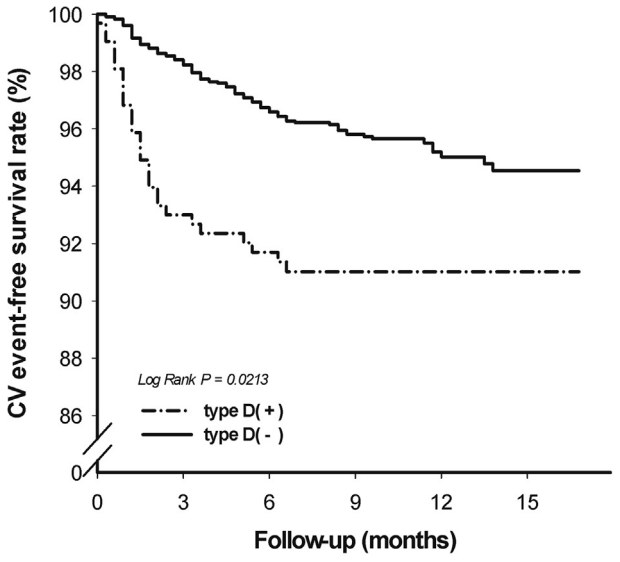


**Fig. 1** The cumulative hazard of future cardiovascular events in stable CAD patients with and without type D personality (type D).

patients with type D personality than in patients who did not have this personality type (p = 0.0157). Table 3 shows the association between type D personality and the risk of future CV events among the study patients. The crude hazard ratio (HR) for future CV events of CAD patients with type D personality was 2.24 (95% CI, 1.14–4.37). After adjusting for other confounders, type D personality remained associated with a significantly higher risk of future CV events (HR: 3.21, 95% CI: 1.06–9.69). Subgroup analysis of type D personality showed that this personality type was associated with higher risk of total CV events among females (HR: 4.81, 95% CI: 1.35–17.19), the elderly (HR:2.49, 95% CI: 1.06–5.85), those with hypertension (HR: 2.19, 95% CI: 1.04–4.61), those with diabetes (HR: 2.51, 95% CI: 1.14–5.50), and non-smokers (HR: 1.90, 95% CI: 0.88–4.10) (Fig. 2).

## Discussion

The major findings of this study demonstrated that type D personality could be independently associated with an increased risk of future CV events in stable CAD patients with a previous PCI. Furthermore, the risk profile of type D

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**Table 3** Type D personality and future adverse CV event by Cox regression analysis.

| | Total subjects | | Type D (−) | | Type D (+) | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Events (+) | 42 | 5.41 | 30 | 4.58 | 12 | 9.84 |
| No Events (−) | 735 | 94.59 | 625 | 95.42 | 110 | 90.16 |
| Crude HR (95% CI) | | | 1 (referent) | | 2.24 (1.14−4.37) | |
| Model 1 HR (95% CI) | | | 1 (referent) | | 2.08 (1.05−4.10) | |
| Model 2 HR (95% CI) | | | 1 (referent) | | 3.21 (1.06−9.69) | |

Model 1: adjusted for sex, gender, age, diabetes.
Model 2: adjusted for sex, gender, age, diabetes, Buttock, Glucose, HDL-C, eGFR, Average diameters of stent, use of statin and ACE inhibitor/ARB.

personality was even more significant in females, non-smokers, patients with older age, patients with hypertension, and patients with type 2 diabetes. Accordingly, our findings showed that type D personality may help to clarify previous controversies about the association of type D personality and CV outcome. The results should be taken into consideration with other major risk factors to stratify and identify high-risk patients.

While psychosocial factors have been mentioned for decades as potential contributing factors to CV disease, the connection between particular types of personalities and individual CV diseases remains inconclusive. Various associations have been reported between different CV diseases and personality traits, such as type A (high strung), type B (easy going), and type D (distressed type).[17–19] Recent evidence further points to closer connections of personality traits with CV diseases, especially type D personality. Type D personality represents the effects of NA and SI personality traits.[1] Type D personality might be associated with poor clinical outcomes in patients with congestive heart failure or peripheral arterial occlusive disease after receiving open-heart surgery and after receiving an implantable cardioverter-defibrillator (ICD).[20] Accordingly, type D personality may be considered an important risk factor that should be mentioned for risk stratification in some CV diseases.

However, the association between type D personality and CV risk is inconsistent. Kelpis et al. reported that type D personality was associated with the occurrence of post-operation atrial fibrillation, but it was not associated with other complications after coronary surgery.[21] Meyer et al. reported that type D personality was not related to future risk in CAD patients receiving PCI.[10] However, it was argued that patients with type D personality were younger than those without type D personality in their study (age 61 years vs. 64 years on average), which might be the reason why type D personality was not a risk factor for future events.[10]

In our study, the average age was similar between the patients with and without type D personality. Our findings were compatible with previous findings on the poor

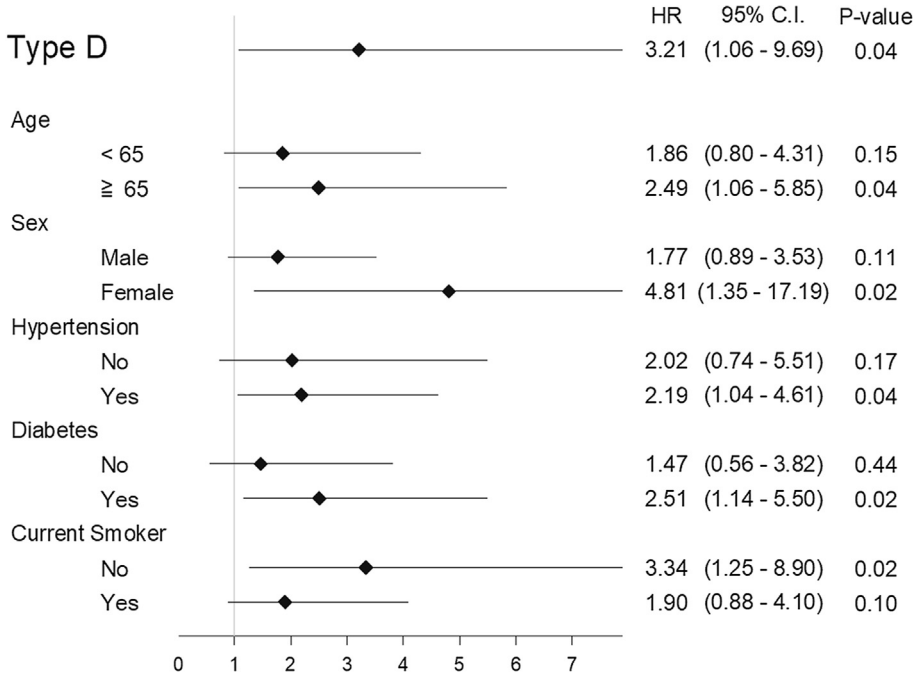


**Fig. 2** Hazard ratios of type D personality in CAD patients after PCI in subgroup analysis, by proportional hazards regression analysis.

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prognostic value of type D personality in CAD patients. Recently, Grande et al. reported that type D personality may affect the prognosis in CAD patients.[12] Moreover, it was shown that type D personality remained an independent predictor of adverse outcomes after adjusting for all other variables in patients treated with drug-eluting stents.[22] The majority of international studies on type D personality indicated that the prevalence of the personality type is between 15% and 29% in CV patients.[21,23] Although our study is not an epidemiological study, the observed prevalence of type D personality (15.7%) in our CAD patients was still within the reported range.

There are several potential mechanisms through which type D personality may have an adverse influence on the prognosis in patients with CAD. It was shown that the cortisol awakening response could be elevated, suggesting dysregulation of the hypothalamic—pituitary—adrenal axis in acute coronary syndrome patients with type D personality.[24] Additionally, type D personality was independently associated with reduced heart rate recovery in chronic heart failure patients, which may represent autonomic dysfunction.[25] These abnormalities in the adrenergic endocrine system and autonomic functions may result in increased plasma levels of inflammatory cytokines.

Increased serum levels of C-reactive protein[26] and tumor necrosis factor[27] were found in subjects with type D personality, suggesting increased baseline inflammation with this personality type. Additionally, oxidative stress may also contribute to increased future risk in some patients with type D personality.[28] Kupper et al. reported higher oxidative stress, lower antioxidants, and an increased oxidative stress ratio in CHF patients with type D personality.[28] Furthermore, it was indicated that type D personality may theoretically contribute to the development of some CV diseases through behavior issues that include sedentary lifestyle,[29] poor self-care, poor medication adherence, and unhealthy diet.[30] These physiological processes and behavior pathways may in turn cause vascular endothelial dysfunction and atherosclerosis, which eventually increase the risk of CV and cerebrovascular events later in life.

For the first time, this study showed that in an Asian cohort with stable CAD, type D personality could be independently associated with an increased risk of future CV events. The subgroup analysis showed that type D personality was especially associated with increased risk among females, non-smokers, hypertension patients, and diabetes patients. Diabetes and hypertension are well-established cardiovascular risk factors, and it is very important to identify other independent predictors in addition to these traditional risk factors. People with type D personality show more difficulties in realizing self-health management behaviors and poor adherence to medical therapy, leading to the occurrence of organ damage as a consequence of diabetes and hypertension, such as neuropathy, retinopathy, and micro- and macrovascular complications.[31]

Nefs et al. reported a 29% prevalence of type D personality in patients with diabetes, confirming the connection between personality type and this disease.[32] Conti et al. showed that type D personality is a significant predictor of poor medication adherence and unhealthy behavior.[31] The present study showed that type D personality contributed to higher risk among hypertension and diabetes patients, which further supports the importance of this personality type in risk stratification among patients with CV risk.

For females and non-smokers, it is very important to identify independent predictors for these unique groups. Sex differences have been reported in the pathogenesis of CAD between men and women. Men suffered most frequently from occlusive CAD, but women more frequently exhibit non-obstructive CAD or microvascular dysfunction.[33] Furthermore, men develop CAD earlier and usually present with more severe atherosclerosis in their coronary arteries than women, suggesting possible variable pathogenesis between men and women. Although the underlying mechanism remains undetermined, this study showed that type D personality has modification effects among these unique populations and could be used as an important predictor for future adverse events.

There are some limitations that should be addressed in this study. The study was limited to an Asian cohort of ethnic Chinese in Taiwan, and the findings should be validated in different populations before they are universally applied. Accordingly, this study may be seen as a pilot study. Future clinical studies are needed to confirm if enhanced risk management would be helpful for secondary prevention in CAD patients with type D personality. Some confounders such as dietary information, physical activity, and exercise were also not included as covariates, which is another limitation of this study.

Moreover, the information of depression was not collected. Depression and CVD are bidirectionally related, meaning that they are mutual risk factors for each other, and they often co-exist. Associations between depression[34] and anxiety[35] with CVD have been mentioned, and depression may be confounded with the effect of type D personality.[36] Although we did not adjust for the depression symptoms or scores in our analysis, most type D patients did not meet the diagnostic criteria for depression.[37,38] In a review of type D and CVD outcomes, type D personality remained independently associated with an increased risk of clinical events after adjustment for co-occurring depression symptoms and scores, suggesting that both constructs involve distinct disease pathways.[38] Denollet et al. suggested that type D represents a general propensity to psychological distress and is better than depression or anxiety in the prediction of cardiac outcome.[38]

In conclusion, type D personality was independently associated with an increased risk of future CV events in an Asian cohort of stable CAD patients with a previous PCI. The prognostic value of type D personality was even more significant among the females, non-smokers, the elderly, hypertensive patients, and type 2 diabetic patients. Our findings suggest potential psycho-somatic connections in clinical outcomes of CAD patients and could help to identify high-risk groups of patients after PCI. Future clinical observations and interventional studies are required to validate the prognostic role of type D personality in advanced risk stratification for the secondary prevention of stable CAD patients with different ethnicities in different areas.

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## Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jfma.2018.08.021.

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