Network analysis of anxiety and depressive symptoms among patients with cardiovascular disease

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Abstract

Background Patients with cardiovascular disease (CVD) often experience anxiety and depression. However, the central and bridge symptoms of anxiety and depression among patients with CVD remain unclear. Network analysis is a statistical method that can reveal and visualise complex relationships between multiple variables. This study aimed to identify the central and bridge symptoms in the anxiety-depression network, which may provide potential targets for preventing and intervening in anxiety and depression.

Methods A total of 1180 patients with CVD were selected from the Psychology and Behavior Investigation of Chinese Residents. The survey was conducted from July 10 to September 15, 2021. Face-to-face electronic questionnaires were distributed to respondents by the investigators. The Generalized Anxiety Disorder 7 (GAD-7) and Patient Health Questionnaire-9 were used to assess anxiety and depressive symptoms among patients with CVD. Network analysis was conducted using R4.02 to identify central and bridge symptoms in the anxiety-depression network.

Results Among the 1180 patients with CVD included in this study, 673 (57%) were male and 507 (43%) were female. More than half (53.5%) of patients were under 60 years old. The mean GAD-7 score was 4.66±4.38, and 169 (14.3%) patients had anxiety symptoms. The mean PHQ-9 score was 6.29±5.29, and 235 (19.9%) had depressive symptoms. Furthermore, 144 (12.2%) patients people had both anxiety and depressive symptoms. In the network of anxiety and depressive symptoms, "unable to sit still because of anxiety", "feeling afraid that something terrible is about to happen", and "feeling bad or like a failure, or disappointing oneself or family" were the most influential and central symptoms. We also found that "feeling afraid that something terrible is about to happen" and "thoughts of dying or hurting oneself in some way" were pivotal bridge symptoms between anxiety and depression.

Conclusions This study provides new insights into the network structure of anxiety and depression in patients with CVD. These identified central and bridge symptoms may be potentially effective targets for preventing anxiety and depression in patients with CVD, and may provide treatment strategies for patients with anxiety and depression.

Keywords Cardiovascular disease, Anxiety, Depression, Network analysis, Central and Bridge symptoms

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Introduction

Cardiovascular disease (CVD) is one of the most common chronic diseases, mainly including ischemic heart disease, arrhythmia, stroke, congestive heart failure [1], and hypertension [2]. CVD is the most common cause of death worldwide, accounting for 31% of all deaths worldwide [3]. In 2018, there were approximately 290 million CVD patients in China, of which 13 million suffered from stroke and 11 million from coronary heart disease [4]. With the progress of aging, the incidence of CVD is also constantly increasing. Two fifths of deaths in China are attributed to CVD, which is higher than cancer or other diseases [3, 5]. In addition to death, CVD also brings a huge economic burden, resulting in a significant proportion of healthcare expenditures and productivity losses [6]. Furthermore, patients with CVD often experience a series of physical, mental, social, and emotional discomforts, which often lead to more psychological problems [7]. Compared with ordinary adults, patients with CVD have a higher incidence of psychological disorders, mainly manifested as anxiety and depressive symptoms [8].

Anxiety is common among patients with CVD, with a prevalence three times higher than that in the general population [9]. Anxiety is an adaptive response characterized by physical and cognitive symptoms, arising from a state of unease and excitement from real or imagined danger [10]. Patients with CVD may experience anxiety due to hospitalization, low education level, prolonged disease duration, fear of death and uncertainty, unfamiliar environment, and invasive interventions [11]. Existing evidence suggests that anxiety can affect an individual's quality of life, daily functioning, and overall well-being [12]. Higher levels of anxiety have been shown to be important predictors of recurrent cardiac events [9, 13]. A meta-analysis suggests that anxiety is associated with a 41% increased risk of cardiovascular death [14]. Therefore, it is necessary to pay attention to the anxiety symptoms of patients with CVD.

As CVD is an irreversible chronic disease, after diagnosis, in addition to the physical health damage caused by the disease itself, the cost of long-term drugs treatment can also impose an economic burden on patients. At the same time, the suddenness and severity of the disease can also bring psychological burden to patients and may lead to depressive symptoms [4]. Depression is widely defined as an emotional disorder associated with reduced vitality, decreased motivation to engage in pleasurable activities, accompanied by extreme fatigue, discouragement, and loss of meaning in life [15]. Depression may lead to mental stress and activate the hearts' sympathetic nervous system, resulting in reduced blood flow, increased heart rate, left ventricular hypertrophy, myocardial infarction, and sudden cardiac death [16, 17]. In addition, patients with depression often tend to have unhealthy lifestyles, such as lack of physical activity, processed diets, weight gain, and smoking, leading to obesity and insulin resistance, which may further exacerbate the progression of CVD [18]. Depression is common in patients with CVD and is associated with cardiovascular death and disability, leading to increased healthcare costs and decreased quality of life [19]. Therefore, paying attention to depressive symptoms may be of great significance for improving the prognosis of patients with CVD.

Anxiety and depression are common among patients with CVD. They increase the risk of cardiac events and are associated with worse outcomes [20]. Anxiety and depression symptoms can complicate CVD management by amplifying pain perception, altering sleep, and exacerbating fatigue, all of which further hinder recovery and rehabilitation [21, 22]. Due to the overlap between CVD symptoms and psychological symptoms, anxiety and depressive symptoms in patients with CVD are often not recognized and treated [23]. Inadequate understanding and management of anxiety and depression may exacerbate symptoms of CVD, leading to impaired cognitive function, disruption of social and occupational functioning, and even higher risk of mortality [24]. Previous studies have explored the influencing factors [25] and intervention strategies [26] of anxiety and depression in patients with CVD. However, the central and bridge symptoms of anxiety and depression in patients with CVD remain unclear.

Network analysis is a statistical method that can reveal and visualise complex relationships between multiple variables and identify potential influencing factors [27]. Network analysis uses symptoms as nodes and the relationships between symptoms as edges, and visualises the interrelationships between nodes in the network through nodes and edges, forming a network [28]. The aim of network analysis is to identify central symptoms and bridge symptoms, and has potential applications in clinical interventions aimed at preventing comorbidity development and providing targeted therapy [29]. The central symptom represents the symptom that is the strongest connections with other symptoms and can targeted as prominent symptom of concern in clinical practice [30]. Bridge symptoms highly connects two different symptom clusters, playing a crucial transmission role in symptoms from one cluster to another [31]. Network analysis has been used to explore anxiety and depressive symptoms in different populations, such as patients with diabetes [32], adolescents [33], and older adults [34]. Ma et al. [35] explored the network analysis of depression and anxiety symptoms and their associations with life satisfaction among hypertensive older adults. However, to our knowledge, the central and bridge symptoms of anxiety and depression in other patients with CVD, such as coronary

heart disease, stroke, arrhythmia, and non hypertensive older adults, have not yet been explored. Accurately identifying the central and bridge symptoms in the anxiety and depression network may provide more information for targeted intervention policies.

Therefore, the objective of this study was to explore the network characteristics of anxiety and depressive symptoms among patients with CVD and to identify central and bridge symptoms. We assumed that the network of anxiety and depressive symptoms had key symptoms influencing others, and that this network was closely related to several central symptoms.

Methods

Study design and participants

The data for this study were derived from the Psychology and Behavior Investigation of Chinese Residents (PBICR). PBICR is an open, large-scale, nationally representative study initiated by the School of Public Health, Peking University [36]. The survey was conducted from July 10 to September 15, 2021. The survey targeted residents of 120 cities in 23 provinces, five autonomous regions, and four municipalities directly under the central government in China and adopted a multi-stage sampling method using stratified sampling in cities, regions, counties, and communities and quota sampling from the community to the individual level. Trained investigators conducted the survey. Face-to-face electronic questionnaires were distributed to respondents by the investigators, and the questionnaires were obtained by scanning the QR code. The investigators received comprehensive training on the PBICR survey. Researchers who strictly followed trained investigation procedures were considered eligible to participate in this study. This study was approved by the Ethics Committees of the Health Culture Research Center of Shaanxi (JKWH-2021-01) and Jinan University (JNUKY-2021-018). All participants fully understood the survey and voluntarily signed an informed consent form.

Participants included in this study were patients with CVD. Cardiovascular disease includes ischemic heart disease, arrhythmia, stroke, congestive heart failure [1], and hypertension [2]. The inclusion criteria were as per the following: (1) age ≥ 18 years; (2) suffering from coronary heart disease, stroke, and/or hypertension diagnosed by a doctor; (3) can complete the online survey by oneself or with the help of an investigator; (4) being able to understand the meaning conveyed by each item in the questionnaire. Participants were excluded if they had confusion, mental abnormalities, or cognitive dysfunction. After excluding questionnaires with incomplete information, the study included a sample size of 1180. According to the sample size requirements of the network models [37], each edge parameter requires at least to 3–5 samples. The required edge parameters in the

network are (total number of nodes) * (total number of nodes − 1)/2. The number of nodes in this study was 16, and the pairing-related parameters were $(16 \times 15)/2 = 120$. The required sample size was 360–600, which met the requirements of network analysis.

Measurements

Anxiety symptoms

The Generalized Anxiety Disorder 7 (GAD-7) [38] was used to assess anxiety symptoms in patients with CVD. The reliability and validity of the GAD-7 was excellent and to be applicable to Chinese population [39]. The questionnaire consists of seven items. The rating range for each item is 0–3 points, with 0 indicating none at all, 1 indicating a few days, 2 indicating more than 7 days, and 3 indicating almost every day. The total score is between 0 and 21 points. Higher scores indicate more severe anxiety symptoms. A total greater than or equal to 10 points indicates the presence of anxiety symptoms. In the current research, the Cronbach's α coefficient of GAD-7 was 0.941.

Depressive symptoms

The Patient Health Questionnaire-9 (PHQ-9) [40] was used to assess depressive symptoms in patients with CVD. The Chinese PHQ-9 has been widely validated with good psychometric properties [41]. The questionnaire consists of nine items. The rating range for each item is 0–3 points, with 0 indicating none at all, 1 indicating a few days, 2 indicating more than 7 days, and 3 indicating almost every day. The total score is between 0 and 27 points. Higher scores indicate more severe depressive symptoms. A total score greater than or equal to 10 points indicates the presence of depressive symptoms. In the current research, the Cronbach's α coefficient of PHQ-9 was 0.921.

Demographic and health characteristics

The participants' demographic characteristics included age, gender, educational level, and marital status. Health characteristics included body mass index (BMI) and smoking status. Demographic and health characteristics were self-reported by patients.

Statistical analysis

The software of SPSS 25.0 was used to conducted descriptive analysis of continuous and categorical variables, as well as the calculation of the Cronbach's α coefficient of the scale. R4.02 was used to performed a network analysis of anxiety and depression.

Gaussian diagrams model (GGM) were used to evaluate the relationship between anxiety and depressive symptoms. The graph least absolute shrinkage and selection operator (GLASO) was applied to remove weak

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edges to reduce spurious correlations and further regularise the GGM [37, 42]. In the network, each node represents anxiety or depressive symptoms. Edges represent the association between two symptoms, with thicker edges indicating a stronger association. The green and red lines represent positive and negative relationships, respectively. This study conducted network estimation, centrality index analysis, and stability estimation. To evaluate the importance of each node (symptom), three key centrality indicators were calculated; strength, closeness, and betweenness, which mainly assessed the importance of nodes based on strength. Strength is the most commonly used centrality metric, representing the sum of weighted connections of nodes and measuring its importance in the network [43]. The bridge centrality index was calculated to identify the bridge symptoms of anxiety and depression, and its accuracy was evaluated by calculating the 95% confidence intervals (CI) of the marginal weights. A stability evaluation was conducted using the discarded subset guidance of the case studies (2500 guidance samples) to calculate the stability coefficients

Table 1 Sample characteristics ($n = 1180$)

Characteristics	n (%)/ mean ± SD
Age (years)	
<60	673 (53.5%)
≥60	549 (46.5%)
Gender	
Men	579 (57.0%)
Women	507 (43.0%)
Education (years)	
≤12	825 (69.9%)
>12	355 (30.1%)
Marital status	
Single/divorced/widow	193 (16.4%)
Married	987 (83.6%)
Smoking Status	
Never smoking	720 (61.0%)
smoking	230 (19.5%)
had quit smoking	230 (19.5%)
BMI(kg/m^2)	
<18.5	96 (8.1%)
18.5–23.9	595 (50.4%)
24-27.9	390 (33.1%)
≥28	99 (8.4%)
Comorbidity	
Hypertension	825 (69.9%)
Coronary heart disease	50 (4.2%)
Stroke	28 (2.4%)
Hypertension and coronary heart disease	138 (11.7%)
Hypertension and stroke	25 (2.1%)
Hypertension and coronary heart disease and stroke	23 (2.0%)
Hypertension/coronary heart disease/stroke and diabetes /dyslipidemia/other	91 (7.7%)
Anxiety symptoms	4.66 ± 4.38
Depressive symptoms	6.29 ± 5.29

related to strength centrality. It is generally believed that the stability coefficient should be greater than 0.5 and at least greater than 0.25. If it is 0.7 or greater, it is optimal [37]. In addition, the Network Comparative Test (NCT) was conducted to evaluate the differences in anxiety and depressive symptoms network models among different ages, educational levels, and marital statuses.The differences between the two groups in terms of global strength and local connectivity were compared using the NCT.

Results

Sample characteristics

Among the 1180 patients with CVD included in this study, 673 (57%) were male and 507 (43%) were female. More than half (53.5%) of patients were under 60 years old, had received less than or equal to 12 years of education (69.9%), had never smoked (61%), had a normal body mass index (50.4%), and had hypertension (69.9%). Most of the patients were married (83.6%). The sample characteristics are listed in Table 1. In this study, the mean GAD-7 score was 4.66 ± 4.38, and 169 (14.3%) patients had anxiety symptoms. The mean PHQ-9 score was 6.29 ± 5.29, and 235 (19.9%) had depressive symptoms. Furthermore, 144 (12.2%) patients people had both anxiety and depressive symptoms. The scores for each item on anxiety and depressive symptoms are presented in Table 2.

Network structure

The network structure of anxiety and depressive symptoms in patients with CVD is shown in Fig. 1. The strongest correlations among anxiety symptoms were GAD5 (unable to sit still because of anxiety) and GAD7 (feeling afraid that something terrible is about to happen) (edge weight = 0.283), followed by GAD2 (unable to stop or control worries) and GAD4 (difficulty relaxing) (edge weight = 0.227). The two most correlated symptoms in the depressive symptom network were PHQ3 (difficulty falling asleep, restless sleep, or excessive sleeping) and PHQ4 (feeling tired or having little energy) (edge weight = 0.271), followed by PHQ6 (feeling bad or like a failure, disappointing oneself or family) and PHQ9 (thoughts of dying or hurting oneself in some way) (edge weight = 0.262). In the cross-network of anxiety and depressive symptoms, the association between GAD7 (feeling afraid that something terrible is about to happen) and PHQ9 (thoughts of dying or hurting oneself in some way) was the strongest (edge weight = 0.145), followed by the association between GAD5 (unable to sit still because of anxiety) and PHQ8 (moving or speaking slowly or too fast) (edge weight = 0.105).

Table 2 The scores for each item of anxiety and depressive symptoms

Item	Mean	SD	Expected Influence
GAD1 Feeling nervous, anxious, or eager	0.71	0.70	1.00
GAD2 Unable to stop or control worries	0.66	0.75	1.03
GAD3 Excessively worried about various things	0.72	0.75	0.98
GAD4 Difficulty relaxing	0.71	0.73	1.02
GAD5 Unable to sit still because of anxiety	0.64	0.73	1.07
GAD6 Becoming easily annoyed or impatient	0.68	0.70	0.89
GAD7 Feeling afraid that something terrible is about to happen	0.55	0.73	1.02
PHQ1 Have little interest in doing things	0.79	0.75	0.89
PHQ2 Feeling down, depressed, or hopeless	0.63	0.73	1.01
PHQ3 Difficulty falling asleep, restless sleep, or excessive sleeping	0.95	0.82	0.64
PHQ4 Feeling tired or having little energy	0.88	0.76	0.96
PHQ5 Loss of appetite or overeating	0.76	0.72	0.89
PHQ6 Feeling bad or like a failure, disappointing oneself or family	0.60	0.75	1.04
PHQ7 Inability to concentrate	0.69	0.76	0.94
PHQ8 Moving or speaking slowly or too fast	0.64	0.77	0.92
PHQ9 Thoughts of dying or hurting oneself in some way	0.36	0.69	0.83

SD: standard deviation; GAD-7: Generalized Anxiety Disorder scale-7; PHQ-9: Patient Health Questionnaire-9

Centrality and Bridge centrality
In the anxiety and depression symptom network, the highest strength node was GAD5 (unable to sit still because of anxiety), followed by GAD7 (feeling afraid that something terrible is about to happen), and PHQ6 (feeling bad or like a failure, disappointing oneself or family). In terms of bridge strength, nodes GAD7 (feeling afraid that something terrible is about to happen) and PHQ9 (thoughts of dying or hurting oneself in some way) were stronger than other nodes. Figure 2 shows the centrality and bridge strength of each node for anxiety and depressive symptoms in patients with CVD.

Network comparison
In this study, the results showed that the scores of anxiety and depression among patients with CVD among different ages ($t = 4.924$, $P < 0.001$; $t = 5.353$, $P < 0.001$), educational levels ($t = -2.368$, $P = 0.018$; $t = -2.109$, $P = 0.035$), and marital status ($t = 4.391$, $P < 0.001$; $t = 4.620$, $P < 0.001$) in patients were significantly different. However, the scores for anxiety and depression between males and females ($t = 1.197$, $P = 0.232$; $t = 1.296$, $P = 0.195$) and BMI ($F = 0.887$, $P = 0.447$; $F = 0.427$, $P = 0.734$) were not significantly different. Therefore, network comparisons were conducted between different age groups, educational levels, and marital statuses. There were no significant differences in edge weight and global strength among the different age groups ($M = 0.139$, $P = 0.950$; $S = 0.030$, $P = 0.802$), educational levels ($M = 0.233$, $P = 0.119$; $S = 0.020$, $P = 0.921$), or marital statuses ($M = 0.214$, $P = 0.465$; $S = 0.154$, $P = 0.475$). Figure 3 shows the results of the network comparison.

Network stability
The stability of the network structure was evaluate by estimating 95% confidence intervals of the edge weights. In this study, the network of anxiety and depressive symptoms was stable with a central stability coefficient of $0.594 > 0.50$. Figure 4 depicts the stability of the centrality. The results of the significance of the edge weights are shown in Supplementary Fig. 1.

Discussion
Network analysis was used to explore the interaction between anxiety and depressive symptoms in patients with CVD. In the network of anxiety and depressive symptoms, GAD5 (unable to sit still because of anxiety), GAD7 (feeling afraid that something terrible is about to happen), and PHQ6 (feeling bad or like a failure, disappointing oneself or family) were the most influential and central symptoms. We also found that GAD7 (feeling afraid that something terrible is about to happen) and PHQ9 (thoughts of dying or hurting oneself in some way) were pivotal bridge symptoms between anxiety and depression. These findings may help us understand the interaction between anxiety and depressive symptoms in patients with CVD, reveal the pathological mechanisms of comorbidity development and the maintenance of anxiety and depression, and provide better insights for potential intervention and treatment strategies.

In this study, 14.3% of patients with CVD had anxiety symptoms, 19.9% had depression symptoms, and 12.2% had both anxiety and depression symptoms. The prevalence of anxiety and depression among patients with CVD in this study was lower than in a previous study [44]. van der Lingen et al. [44] found that the prevalence of anxiety and depression in patients with implantable
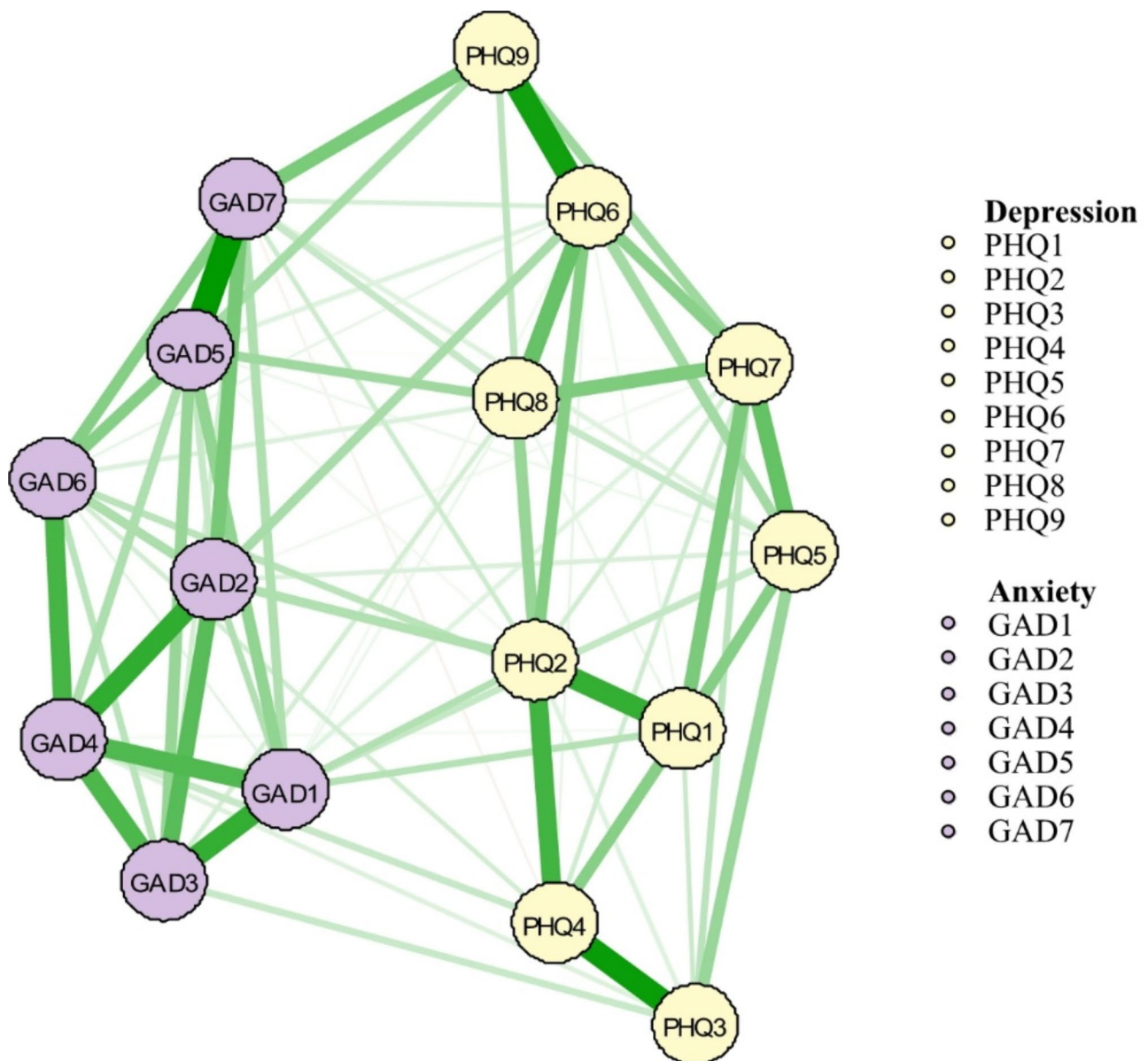
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Fig. 1 The network structure of anxiety and depressive symptom

cardioverter defibrillators were 32% and 35%, respectively. Due to the different methods of measuring anxiety and depression symptoms, different standards and cut-off values of measurement tools, different times of measuring anxiety and depression symptoms during the research process, and different exclusion and inclusion criteria [45], the prevalence of anxiety and depression reported in different studies may vary.

A higher strength value of a node (symptom) indicates a stronger connection and a greater role in the network, thus identifying it as a central symptom [43]. In this study, GAD5 (unable to sit still because of anxiety) was the most central symptom in the network of anxiety and depression. This finding was consistent with

the results of a study on anxiety and depression among medical students [46], but different from other previous studies [47, 48]. A study on people with disabilities [46] and a study on patients with heart failure [48] found that GAD5 (unable to sit still because of anxiety) was a bridge symptom between anxiety and depression symptoms. For patients with CVD, GAD5 (unable to sit still because of anxiety) may be a significant symptom. Patients with CVD are prone to restlessness due to clinical symptoms such as heart pain and other physical discomfort [8]. Furthermore, GAD7 (feeling afraid that something terrible is about to happen) was the central symptom in the network of anxiety and depressive symptoms. This finding was different from a previous study [49]. A network
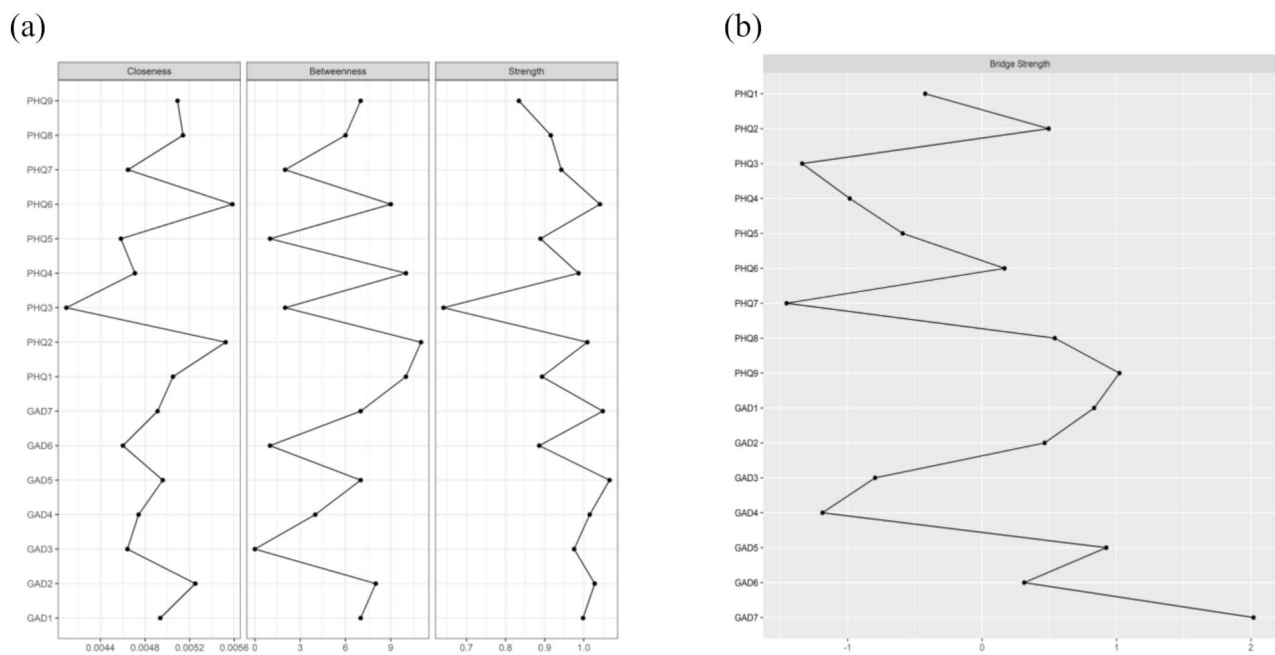
Fig. 2 The centrality and bridge strength of each node of anxiety and depression. (**a**) centrality strength. (**b**) bridge strength
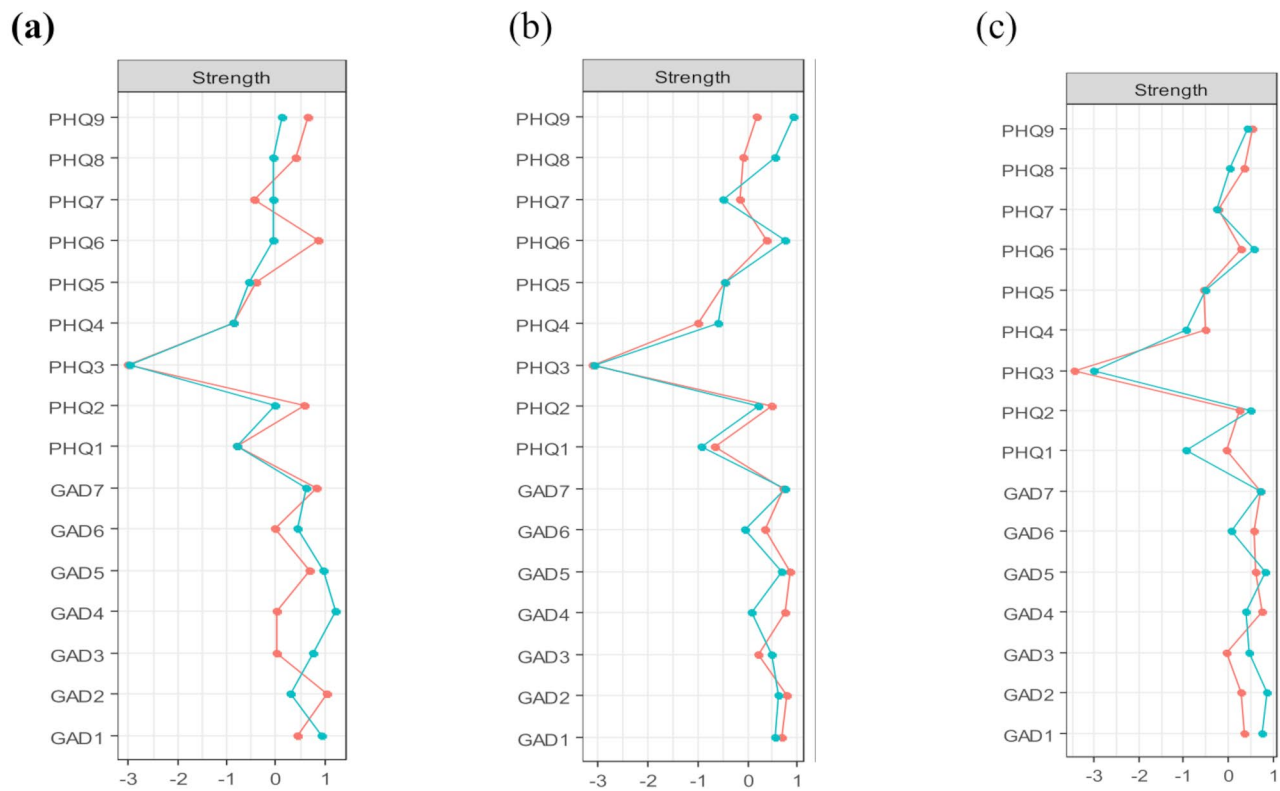

Fig. 3 The results of network comparison. (**a**) different ages; (**b**) different educational levels; (**c**) different marital statuses
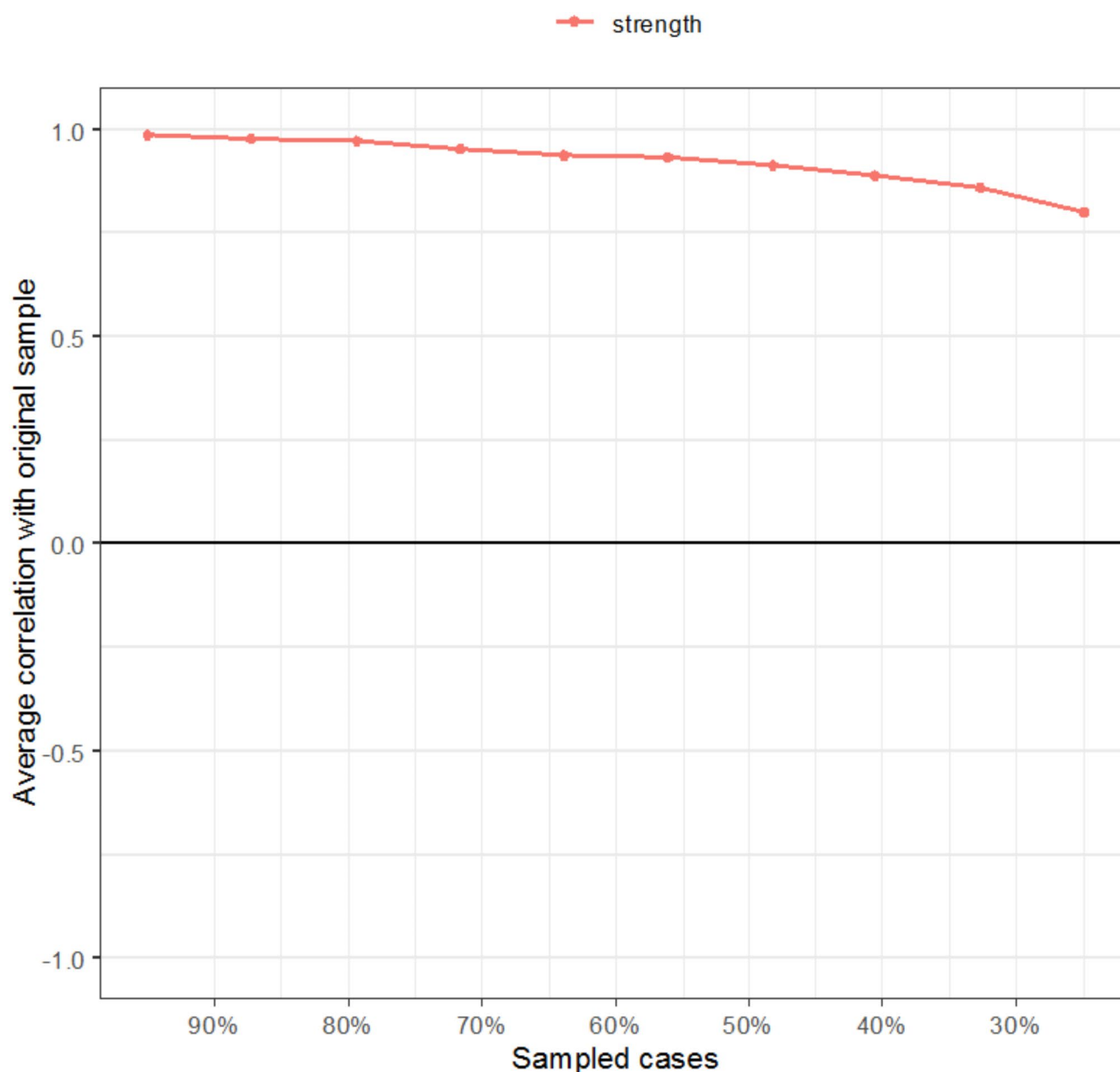
Fig. 4 The stability of centrality

analysis of anxiety and depressive symptoms in tinnitus sufferers found that GAD7 (feeling afraid that something terrible is about to happen) was one of the important bridge symptoms [49]. Patients with CVD may experience a range of adverse physical experiences, including chest pain, reduced cardiac output, and respiratory problems [50], leading to fear and excessive worry. In addition, PHQ6 (feeling bad or like a failure, disappointing oneself or family) was also a central symptom. This finding was inconsistent with previous study [47]. Wang et al. [47] who found that PHQ6 may be an important channel for the interaction between depression and anxiety symptoms. CVD is one of the most common chronic and

life-threatening illnesses, especially in patients with heart failure [8]. Heart failure can lead to a decline in physical function, affect patients' social roles, require dependency on family or friends, and make them feel worthless [51]. Targeted interventions should be implemented for central symptoms such as "unable to sit still because of anxiety", "feeling afraid that something terrible is about to happen", and "feeling bad or like a failure, disappointing oneself or family", because they serve as "target symptoms" in anxiety-depression network among patients with CVD.

Notably, we found that GAD7 (feeling afraid that something terrible is about to happen) and PHQ9 (thoughts

of dying or hurting oneself in some way) were important channels for the interaction between anxiety and depressive symptoms in patients with CVD. GAD7 (feeling afraid that something terrible is about to happen) was the most common bridge symptom in the anxiety and depression network. This result is consistent with previous studies [48, 49]. GAD7 (feeling afraid that something terrible is about to happen) has been found to be a bridge symptom in the network of anxiety and depression in both tinnitus sufferers [48] and patients with heart failure [49]. CVD is a chronic process, and if left untreated for a long time, patients may worry about their prognosis. In addition, PHQ9 (thoughts of dying or hurting oneself in some way) was a bridge symptom in the network of anxiety and depression. A network analysis of anxiety and depression among people with disabilities [47] found that PHQ9 was an important bridge symptom in the network, which supported our findings. A meta-analysis suggested that patients with physical illnesses are more likely to have suicidal thoughts and commit suicide [52], especially when depression is present [53]. The hopelessness theory of depression suggests that adverse external stimuli (such as illness) can easily trigger despair, helplessness, and uselessness in individuals, leading to thoughts of ending life and escaping pain, as well as a more tolerant and accepting attitude towards suicide [54]. Long term care due to illness or weakness can lead to a sense of priceless value, which is considered an indicator of increased suicide risk [55]. Therefore, "fear of something terrible about to happen" and "thoughts of dying or harming oneself in some way" may be important channels for the interaction between anxiety and depression symptoms, playing a prominent role in activating and maintaining anxiety and depression networks.

The central and bridge symptoms highlighted in the networks of anxiety and depression identified through network analysis have potential clinical significance [56]. According to the network theory of psychopathology, interventions targeting important central symptoms may have the greatest effect in disrupting the entire network and reducing its severity, thereby promoting intervention and treatment [57, 58]. This suggests that effective interventions for 'unable to sit still because of anxiety', 'feeling afraid that something terrible is about to happen' and 'feeling bad or like a failure, disappointing oneself or family' may help alleviate psychological distress in patients with CVD. In addition, deactivating important bridge symptoms can disrupt the connections between mental disorders, prevent the transmission of one disease to another, and thus reduce comorbidities [31]. Based on the results of this study, it is recommended to use the bridge symptoms of 'feeling afraid that something terrible is about to happen' and 'thoughts of dying or hurting oneself in some way' as intervention targets for preventing and reducing comorbidities of anxiety and depression. Our findings indicate that intervention strategies focused on central and bridge symptoms, such as mindfulness and cognitive-behavioural therapy, may help prevent and treat anxiety and depression in patients with CVD and reduce comorbidities.

Several limitations of our study should be acknowledged when interpreting our results. First, this was a cross-sectional study, and causal inferences could not be made. Therefore, it is necessary to conduct a longitudinal study to verify these causal relationships. Second, the assessment of anxiety and depression was based on self-reporting, which may have resulted in recall bias, and self-reported symptoms cannot be used as clinically relevant factors, reminding us to interpret the results cautiously. Third, this study focused on patients with CVD in China; therefore, it is unclear whether the results can be extended to other populations. Fourth, patients with CVD have completely different degrees of disease severity, which may directly affect their symptoms of depression or anxiety. Future research should explore the anxiety and depression of patients with different degrees of disease severity. Finally, when conducting network analysis, covariates such as age, gender, and disease severity were not included.

Conclusions

This study provided new insights into the network structure of anxiety and depression in patients with CVD. Our findings revealed that 'unable to sit still because of anxiety', 'feeling afraid that something terrible is about to happen', and 'feeling bad or like a failure, disappointing oneself or family' were the most influential and central symptoms and that 'feeling afraid that something terrible is about to happen' and 'thoughts of dying or hurting oneself in some way' were bridge symptoms within the network of anxiety and depression. These identified symptoms may be potentially effective targets for preventing anxiety and depression in patients with CVD and may provide treatment strategies for these patients.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22269-3.

Supplementary Material 1

Author contributions
Qiuge Zhao designed this study, analyzed data, and wrote manuscript. Yuzhen Zhang analyzed data. Lili Ji and Zhaoqian Pan made substantive intellectual contributions to conceptualization, and revised the manuscript. All authors approved the final version of the manuscript.

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Declarations

Ethics approval and consent to participate
This study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of the Health Culture Research Center of Shaanxi (JKWH-2021-01) and Jinan University (JNUKY-2021-018). Written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Conflicts of interests
The author declares no potential conflicts of interest.

Competing interests
The authors declare no competing interests.

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