Original Article

Associations between waist circumference, central obesity, and the presence of non-valvular atrial fibrillation patients with heart failure

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Background: Reportedly, there is a clear correlation between waist circumference (WC) and atrial fibrillation (AF). However, there is no specific discussion about the relationship between WC and non-valvular AF (NVAF) patients with heart failure. Our main purpose was to study the relationship between WC, central obesity (CO), and NVAF patients with heart failure.

Methods: This is a retrospective cohort study. A total of 3,435 patients with NVAF in the First Affiliated Hospital of Xinjiang Medical University from January 2015 to December 2017 were enrolled. The targeted independent variable and the dependent variable were WC and CO and the presence of NVAF with heart failure, respectively. Univariate, multiple regression, and subgroup analyses were used to analyze their relationship. We used the receiver operating characteristic (ROC) curve to choose the better predictor of NVAF with heart failure between WC and CO and calculated the proposed cut-off value of WC in males and female separately.

Results: The identified risk factors of NVAF with heart failure were sex, height, WC, CO, body mass index (BMI), fasting blood glucose (FBG), homocysteine (HCY), triglyceride (TG), low-density lipoprotein cholesterol (LDLC), hypertension, diabetes mellitus (DM), stroke, vascular disease, and plaque. Then, a binary logistic regression model indicated that the occurrence of NVAF patients with heart failure increased 10% with WC increasing 1 cm and had a 2.8-fold increased risk with CO compared to those without. The predictive value [area under the ROC curve (AUC)], specificity, sensitivity, and accuracy of WC for the disease risk of NVAF with heart failure were higher than those of CO. The proposed cut-off value of WC was 91.85 cm for males and 93.15 cm for females. The diagnostic value of WC for NVAF with heart failure was higher for females than it was for males.

Conclusions: Our research found that WC is related to the presence of heart failure in the patients with NYAF and can predict the presence of NVAF with heart failure. Our findings may help to improve the treatment and care strategies of NVAF individuals with abdominal obesity.

Keywords: Waist circumference (WC); central obesity (CO); non-valvular atrial fibrillation (NVAF); heart failure

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Introduction

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia, which can lead to heart failure, cardiogenic shock, stroke, and thromboembolic disease and endanger life. Heart failure is a complex syndrome caused by abnormal changes in the structure and function of the heart due to a variety of causes, resulting in dysfunction of ventricular contraction or diastolic function, mainly manifested as dyspnea, decreased exercise tolerance, and fluid retention including pulmonary congestion, systemic congestion and peripheral edema, which is the terminal stage of common clinical heart diseases (1,2). In addition, the occurrence of heart failure following atrial fibrillation (AF) was markedly associated with worse clinical outcomes in terms of morbidity and mortality (3). A study has shown that 37% of people with AF had heart failure. Moreover, people with AF have a nearly 2–5 folds increased risk of heart failure (4). Therefore, determination of the intermediate risk factors is useful for detecting AF in patients with heart failure.

Obesity and the metabolic syndrome associated with obesity are major health problems worldwide (5). The prevalence of obesity, in particular abdominal obesity, predisposes people to a series of cardiovascular risk factors (6,7). Waist circumference (WC) and central obesity (CO) are the indicators most often used to gauge centralized distribution of adipose tissues for assessing individual patients. Compared with general obesity evaluation indicators such as body mass index (BMI), WC or CO have higher value in predicting the risk of cardiovascular diseases (8,9).

Limited recent studies have shown that WC has a significant impact on the prognosis of non-valvular AF (NVAF) patients with heart failure or whether it affects medication adherence (10,11). Therefore, our study aimed to explore the effect of WC on NVAF patients with heart failure in the Chinese population, and to determine the effect of WC on prognosis using data from a cohort of nearly 3,000 patients. We present this article in accordance with the STARD reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-170/rc).

Highlight box

Key findings

- Waist circumference is related to the presence of heart failure in non-valvular atrial fibrillation (NVAF) patients and can predict the presence of NVAF patients with heart failure.

What is known and what is new?

- Elevated levels of body mass index and waist circumference were associated with an increased risk of atrial fibrillation.
- For NVAF patients with heart failure, we first found waist circumference can predict the incidence of this disease.

What is the implication, and what should change now?

- Our findings may help to improve the treatment and care strategies of NVAF individuals with abdominal obesity.

Methods

Participants

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This is a retrospective cohort study based on the database of Shang *et al.* (12) which was conducted from January 2015 to December 2017 and included 3,435 NVAF patients at the First Affiliated Hospital of Xinjiang Medical University. After excluding 772 patients who did not answer the information about their WC, 2,663 patients were enrolled in our study. In the original article, the authors reported that the study had been approved by the Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University and that informed consent has been provided by the participants.

Data

In this secondary analysis, WC and CO were used as the exposure variables and NVAF with heart failure was used as the outcome variable. The 2,663 patients were divided into three groups stratified by WC into triples: WC <83.5 cm, 83.5 cm ≤ WC <94 cm, WC ≥94 cm. We defined CO as the dichotomous variable based on the WC measurement standard of the World Health Organization (WHO), clinical action thresholds of the third National

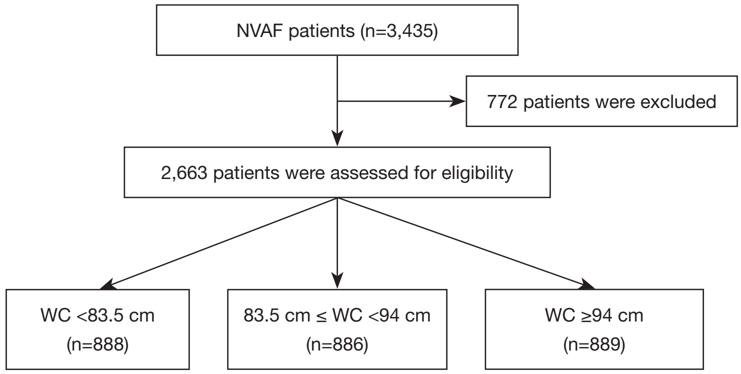

Figure 1 Flowchart. NVAF, non-valvular atrial fibrillation; WC, waist circumference.

Health and Nutrition Examination Survey, and the previous research, with WC ≥94 cm for men and WC ≥80 cm for women being classified as CO (13-15). In this study, continuous variables included age, height, WC, BMI, systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood glucose (FBG), homocysteine (HCY), triglyceride (TG), total cholesterol (TC), and low-density lipoprotein cholesterol (LDLC). Categorical variables included sex, education, smoking, drink, CO, complications such as heart failure, hypertension, diabetes mellitus (DM), stroke, vascular disease, and plaque.

Statistical analysis

Data was analyzed with the use of the statistical package R version 3.4.3 (The R Foundation, Vienna, Austria; http://www.r-project.org). The continuous variables were indicated by mean and standard deviation. The classification variables were expressed as percentages. Analysis of variance (ANOVA) was used to analyze the relationship between continuous variables and categorical variables. Kruskal-Wallis test was used to analyze the relationship among categorical variables. The baseline characteristic table was divided into three groups according to the tertiles of WC. The P value was calculated by parametric and nonparametric tests. Based on the significant variables ($P \leq 0.05$) in univariate analysis, multiple regressions and the subgroup analysis were conducted in order to obtain the result of the trend test for the variables. We created three models: Model 1 adjusted for none; Model 2 adjusted for age and sex; Model 3 adjusted for age, sex, education, smoking, alcohol consumption, height, BMI, SBP, DBP, FBG, HCY, TG, TC, and LDLC, and complications such as heart failure, hypertension, DM, stroke, vascular disease, and plaque. To identify indicators of NVAF patients with heart failure, we performed receiver operating characteristic (ROC) curve analysis. Sensitivity and specificity were then calculated for each of the arithmetic indicators for NVAF patients with heart failure. A P value less than 0.05 indicated that the difference was statistically significant.

Sensitivity analysis

To verify whether the results were reliable, we conducted the following sensitivity analysis: (I) conversion of continuous variables into categorical variables for analysis; (II) univariate analysis and the multiple regressions were conducted to investigate the changes of core results; (III) subgroup analysis was conducted to observe the influence of other factors on the effect of WC and CO on NVAF with heart failure.

Results

Baseline characteristics

After excluding 772 patients who were lacking information about their WC, 2,663 NVAF patients were enrolled in our study (*Figure 1*). *Table 1* shows the distribution of clinical characteristics for different WC groups. There was no significant difference in the general conditions (education, smoking, alcohol consumption) and the complication of stroke between different groups. In the group of WC ≥94 cm, patients with NVAF had the highest probability of the complication of heart failure. In all groups, the probability of complications (hypertension, DM), the clinical data (BMI, systolic, diastolic, FBG, HCY, TG, TC, LDLC), and the average age of patients increased

Table 1 Demographic and clinical data based on the distribution of WC

Variable	WC (cm)			P value	P value*
	<83.5 (n=888)	≥83.5, <94 (n=886)	≥94 (n=889)		
Heart failure, n (%)	19 (2.1)	55 (6.2)	252 (28.3)	<0.001	–
Age, year, mean ± SD	62.5±9.9	63.2±9.9	64.2±9.0	<0.001	<0.001
Gender, n (%)					
Male	292 (32.9)	358 (40.4)	389 (43.8)	<0.001	–
Female	596 (67.1)	528 (59.6)	500 (56.2)	<0.001	–
Education level, n (%)				0.05	–
Primary school and below	470 (52.9)	480 (54.2)	519 (58.4)		
Middle school	250 (28.2)	266 (30.0)	248 (27.9)		
High school or higher	168 (8.9)	140 (15.8)	122 (13.7)		
Current smoking, n (%)	158 (17.8)	163 (18.4)	137 (15.4)	0.21	–
Current drinking, n (%)	764 (86.0)	747 (84.3)	743 (83.6)	0.33	–
Height, cm, mean ± SD	160.7±10.4	162.3±9.1	163.1±8.5	<0.001	<0.001
SBP, mmHg, mean ± SD	137.8±19.5	143.4±21.0	147.7±22.1	<0.001	<0.001
DBP, mmHg, mean ± SD	83.2±11.3	86.0±12.3	86.3±12.6	<0.001	<0.001
FBG, mmol/L, mean ± SD	5.8±1.7	6.1±2.1	6.3±2.1	<0.001	<0.001
TG, mmol/L, mean ± SD	1.5±0.9	1.7±1.1	2.0±1.3	<0.001	<0.001
TC, mmol/L, mean ± SD	4.9±1.1	5.0±1.2	5.1±1.2	0.005	0.002
LDL-C, mmol/L, mean ± SD	2.9±1.0	3.0±0.9	3.1±1.0	<0.001	<0.001
HCY, mmol/L, mean ± SD	12.6±8.8	16.0±10.7	16.3±8.9	<0.001	<0.001
Plaque, n (%)	411 (46.3)	475 (53.6)	467 (52.5)	0.004	–
Hypertension, n (%)	527 (59.3)	584 (65.9)	637 (71.7)	<0.001	–
DM, n (%)	173 (19.5)	198 (22.3)	230 (25.9)	0.005	–
Stroke, n (%)	101 (11.4)	116 (13.1)	106 (11.9)	0.52	–
Vascular disease, n (%)	565 (63.6)	528 (59.6)	517 (58.2)	0.05	–

*, calculated by Kruskal-Wallis *H* test. WC, waist circumference; SD, standard deviation; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; TG, triglyceride; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HCY, homocysteine; DM, diabetes mellitus.

alongside the increasing level of WC.

The relationship of WC and CO on NVAF patients with heart failure

According to the results of the univariate analysis in *Table 2*, the following factors had significant statistical differences with heart failure: age, sex, height, WC, CO, BMI, SBP, FBG, HCY, TG, LDLC, hypertension, DM, stroke, vascular disease, and plaque (P<0.05). However, there was no correlation between NVAF patients with heart failure and education, smoking, alcohol consumption, DBP, TC (P>0.05). In the analysis using baseline clinical characteristics (*Table 1*) and the univariate analysis (*Table 2*), we found a clear positive correlation between both WC and CO and NVAF with heart failure. According to the WHO's criteria, we classified WC into a dichotomous variable (≥94 cm for men and ≥80 cm for women) which we called

Table 2 The univariate analysis of NVAF with heart failure

Variable	With heart failure	OR	95% CI	P value
Age, year, mean ± SD	63.3±9.6	1.0	1.0, 1.0	<0.001
Male, n (%)	1,039 (39.0)	1.0	1.0, 1.0	<0.001
Female, n (%)	1,624 (61.0)	0.6	0.5, 0.7	<0.001
Education level, n (%)				
Primary school and below	1,469 (55.2)	1.0	1.0, 1.0	<0.001
Middle school	764 (28.7)	0.9	0.7, 1.2	0.64
High school or higher	430 (16.1)	0.8	0.6, 1.2	0.30
Current smoking, n (%)	458 (17.2)	1.0	0.8, 1.4	0.88
Current drinking, n (%)	2,254 (84.6)	0.8	0.6, 1.1	0.25
Height, cm, mean ± SD	162.0±9.4	1.0	1.0, 1.0	0.002
WC, cm, mean ± SD	88.5±11.7	1.1	1.1, 1.1	<0.001
CO, n (%)	1,530 (57.5)	3.8	2.8, 5.0	<0.001
SBP, mmHg, mean ± SD	142.9±21.3	1.0	1.0, 1.0	<0.001
DBP, mmHg, mean ± SD	85.2±12.2	1.0	1.0, 1.0	0.13
FBG, mmol/L, mean ± SD	6.1±2.0	1.1	1.0, 1.1	0.04
HCY, mmol/L, mean ± SD	15.0±9.6	1.0	1.0, 1.0	0.002
TG, mmol/L, mean ± SD	1.7±1.1	1.1	1.0, 1.2	0.01
TC, mmol/L, mean ± SD	5.0±1.2	1.1	1.0, 1.2	0.08
LDLC, mmol/L, mean ± SD	3.0±1.0	1.2	1.0, 1.3	0.02
Plaque, n (%)	1,353 (50.8)	1.9	1.5, 2.4	<0.001
Hypertension, n (%)	1,748 (65.6)	1.5	1.1, 1.9	0.003
DM, n (%)	601 (22.6)	1.3	1.0, 1.7	0.03
Stroke, n (%)	323 (12.1)	1.7	1.2, 2.3	<0.001
Vascular disease, n (%)	1,610 (60.5)	0.7	0.6, 0.9	0.005

NVAF, non-valvular atrial fibrillation; OR, odds ratio; CI, confidence interval; SD, standard deviation; WC, waist circumference; CO, central obesity; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBG, fasting blood glucose; HCY, homocysteine; TG, triglyceride; TC, total cholesterol; LDLC, low-density lipoprotein cholesterol; DM, diabetes mellitus.

CO (16). In the non-adjusted model in *Table 3*, the disease risk of NVAF with heart failure increased by 10% with an increase of WC of 1 cm. Similarly, patients with CO had a 2.8-fold increased risk of disease progression compared with those without CO. We observed similar results in the minimally adjusted model and the fully adjusted model. Therefore, WC and CO were independent predictors of NVAF with heart failure respectively. As shown in *Table 3*, each body mass index (BMI) category had a strong correlation with the presence of NVAF patients with heart failure in the non-adjusted model and the minimally adjusted model, but there was no significant association in the fully adjusted model, indicating that BMI was not an independent predictor of the presence of NVAF patients with heart failure.

The results of the sensitivity analyses

The subgroup analysis displayed in *Table 4* was conducted to explore the relationship between WC and NVAF with heart failure in each stratification of age, sex, height, SBP, DBP, TG, TC, and LDLC. Each stratification adjusted for

Table 3 The multiple regressions of WC/CO and NVAF with heart failure

Exposure	Non-adjusted model OR (95% CI)	Minimally-adjusted model OR (95% CI)	Fully-adjusted model OR (95% CI)	P value
WC, cm	1.1 (1.1, 1.1)	1.1 (1.1, 1.1)	1.1 (1.1, 1.1)	<0.001
<83.5	Ref	Ref	Ref	
≥83.5, <94	3.0 (1.8, 5.1)	2.9 (1.7, 4.9)	2.6 (1.5, 4.6)	<0.001
≥94	18.1 (11.2, 29.2)	17.2 (10.6, 27.7)	15.7 (9.3, 26.6)	<0.001
CO	3.8 (2.8, 5.0)	6.0 (4.4, 8.3)	6.0 (4.2, 8.4)	<0.001

Non-adjusted model adjusted for none; minimally-adjusted model adjusted for age and sex; fully-adjusted model adjusted for age, sex, education, smoking, drink, height, systolic, diastolic, FBG, HCY, TG, TC, LDLC and complications such as heart failure, hypertension, DM, stroke, vascular disease, and plaque. WC, waist circumference; CO, central obesity; NVAF, non-valvular atrial fibrillation; OR, odds ratio; CI, confidence interval; FBG, fasting blood glucose; HCY, homocysteine; TG, triglyceride; TC, total cholesterol; LDLC, low-density lipoprotein cholesterol; DM, diabetes mellitus.

all the factors (age, height, SBP, DBP, FBG, HCY, TG, TC, LDLC, sex, education, smoking, alcohol consumption, CO, hypertension, DM, stroke, vascular disease, and plaque) except the stratification factor itself. We found that the value of the odds ratio (OR) was above 1, indicating that the relationship of WC and NVAF with heart failure within each stratification of the factors above was consistent and all the covariates were risk factors. Furthermore, an interaction between age, sex, and WC were observed in our study. According to the interaction P value, the effect of WC on NVAF patients with heart failure was significantly different according to age and sex (P<0.05). Our results indicated that WC was positively associated with NVAF patients with heart failure in male [OR =1.08, 95% confidence interval (CI): 1.06–1.1].

The predictive value of WC and CO for the disease risk of NVAF with heart failure

To determine the most predictive and minimalistic model, we plotted ROC curves for the disease risk of NVAF with heart failure (*Figure 2*, *Table 5*). Our results observed that WC had higher predictive power than CO (0.638) and BMI (0.619), with an area under the ROC curve (AUC) of 0.785 (P<0.0001). Compared with CO and BMI, WC in general had better specificity (0.6688:0.4591), sensitivity (0.8466:0.8160) and accuracy (0.6906:0.5028). Furthermore, the proposed cut-off value of WC for predicting NVAF with heart failure is 91.85 cm for males and 93.15 cm for females. The diagnostic value of WC for NVAF with heart failure was higher for females than it was for males and its AUC is larger (0.821:0.736) (*Figure 3*).

Discussion

This study is the first to investigate the influence of WC and CO on NVAF patients with heart failure. Our study is based on a secondary analysis of 2,663 patients. The identified risk factors of NVAF with heart failure were sex, height, WC, CO, FBG, HCY, TG, LDLC, hypertension, DM, stroke, vascular disease, and plaque. Then, a binary logistic regression model indicated that the occurrence of NVAF patients with heart failure increased 10% with WC increasing 1 cm and had a 2.8-fold increased risk with CO compared to those without. Furthermore, the predictive value (AUC), specificity, sensitivity and accuracy of WC for the disease risk of NVAF with heart failure were higher than CO. Our proposed cut-off value of WC for is 91.85 cm for males and 93.15 cm for females. The diagnostic value of WC for NVAF with heart failure was higher for females than it was for males.

Obesity is a multifactorial disease, which is caused by the imbalance between energy intake (EI) and total energy expenditure (TEE) (16,17). This imbalance will lead to the accumulation of excess fat in the body and is related to changes in many metabolic pathways (18,19). A previous study has shown that the 1-year mortality risk of AF patients was negatively related to high BMI, and was directly related to the presence of chronic kidney disease, carotid stenosis, and chronic heart failure in the cohort of AF patients (20). In underweight and normal-weight Asian populations, BMI variability, particularly weight gain, has been associated with an increased risk of new-onset AF and myocardial infarction (21). Obesity, no matter whether defined by BMI or WC, is significantly associated with AF (22). WC and CO have a stronger correlation with the prevalence of

Table 4 The subgroup analysis of the relationship between WC and NVAF with heart failure

Variable	N	OR	95% CI	Interaction P value
Age (year)				<0.001
40–58	804	1.13	1.10, 1.16	
59–67	971	1.14	1.11, 1.17	
68–96	888	1.06	1.04, 1.07	
Sex				0.01
Male	1,039	1.08	1.06, 1.10	
Female	1,624	1.11	1.09, 1.13	
Height (cm)				0.21
150–158	884	1.09	1.07, 1.12	
158.1–164.9	743	1.12	1.09, 1.15	
165–189	1,036	1.10	1.08, 1.11	
SBP (mmHg)				0.19
87–131	852	1.10	1.08, 1.13	
132–149	829	1.11	1.09, 1.14	
150–238	977	1.08	1.06, 1.10	
DBP (mmHg)				0.55
43–79	677	1.10	1.07, 1.13	
80–89	962	1.11	1.08, 1.13	
90–159	1,019	1.09	1.07, 1.11	
TG (mg/dL)				0.48
0.09–1.16	877	1.09	1.06, 1.11	
1.17–1.79	885	1.09	1.07, 1.12	
1.8–11.1	890	1.11	1.08, 1.13	
TC (mg/dL)				0.43
0.27–4.49	872	1.09	1.07, 1.12	
4.5–5.44	890	1.11	1.09, 1.13	
5.45–9.31	886	1.09	1.07, 1.11	
LDLC (mg/dL)				0.18
0.06–2.49	872	1.09	1.08, 1.13	
2.5–3.29	880	1.11	1.09, 1.14	
3.3–7.1	894	1.08	1.06, 1.10	

NVAF, non-valvular atrial fibrillation; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglyceride; TC, total cholesterol; LDLC, low-density lipoprotein cholesterol; OR, odds ratio; CI, confidence interval.

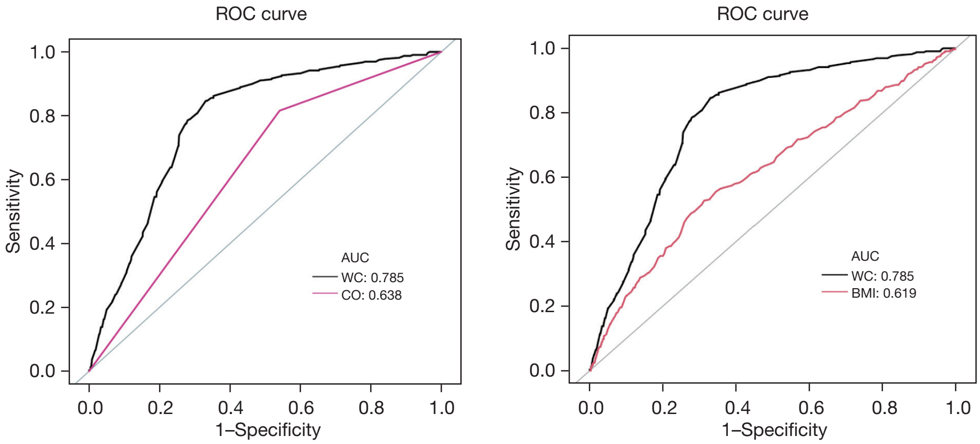

Figure 2 ROC curve for the various anthropometric indices (WC, CO, BMI) and NVAF with heart failure. ROC, receiver operating characteristic; AUC, are under the curve; WC, waist circumference; CO, central obesity; BMI, body mass index; NVAF, non-valvular atrial fibrillation.

Table 5 The comparison between WC and CO in prediction of NVAF with heart failure

Variable	WC	CO
AUC	0.785	0.638
Specificity	0.6688	0.4591
Sensitivity	0.8466	0.8160
Accuracy	0.6906	0.5028

WC, waist circumference; CO, central obesity; NVAF, non-valvular atrial fibrillation; AUC, area under the curve.

cardiovascular disease because they can identify individuals with low body weight but increased ectopic fat accumulation (19,23-25). Abdominal obesity has been highlighted as an important, potentially modifiable risk factor for AF in non-obese Asian populations (26). The American Diabetes Association (ADA) recommends that WC be measured as an alternative indicator of abdominal fat, because it is related to the risk of heart metabolism and emphasizes the difficulty of accurately measuring abdominal fat (27). They quoted WC >102 cm for males and WC >88 cm for females to evaluate the increased risk of heart metabolic disease (28). In addition, WC is associated with congestive heart failure and all-cause mortality independently in patients with type 2 diabetes (16).

Our research has several benefits. First, this is the first time that WC, as an indicator of abdominal obesity, has been utilized to predict the incidence of NVAF with heart failure. Further, our study indicated that the cut-off value of WC for predicting -presence of NVAF with heart failure should be 91.85 cm for males and 93.15 cm for females. However, the validity of this research may be limited to the ethnic group being studied. Therefore, more investigations should be conducted to probe the obesity risk in this category of patients. Our findings indicated that clinical and public health interventions should aim to maintain optimal WC level, which might be an efficient approach to prevent the development of AF.

Our study has several limitations. Firstly, the cases included were Chinese patients with NVAF and thus it has certain geographical and ethnic limitations. Secondly, due to our inclusion standards, the cases did not include patients who had a history of carotid endarterectomy, carotid artery stent implantation or had experienced significant carotid malformation. Thirdly, because this study is a secondary analysis, we can only adjust the original variables in the database.

Conclusions

Our research revealed that WC is related to the presence of heart failure in the patients with NYAF and can be used to predict the presence of NAVF patients with heart failure. Our findings may help to improve the treatment and care strategies of patients with heart failure and abdominal obesity.

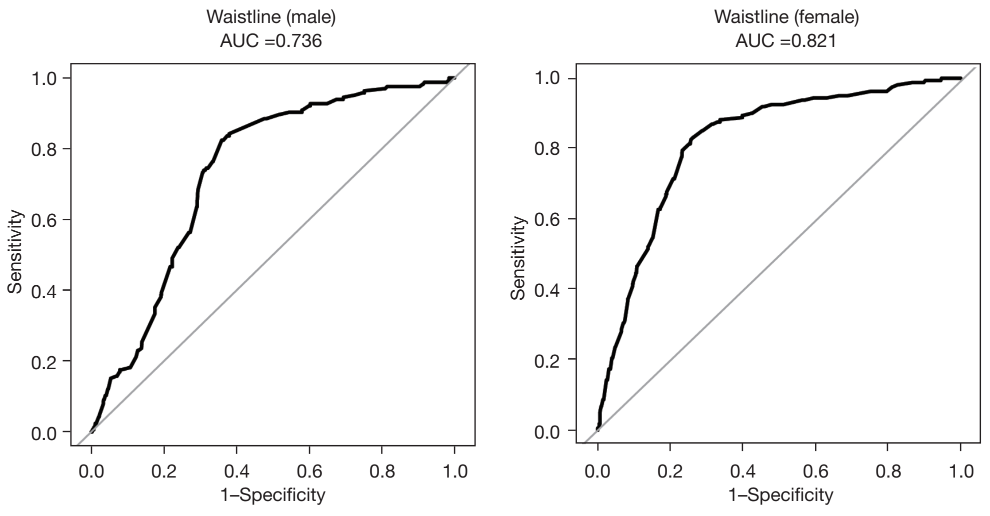

Figure 3 ROC curves of WC for evaluation of NVAF with heart failure. In male patients (sex =1); in female patients (sex =2). AUC, area under the curve; ROC, receiver operating characteristic; WC, waist circumference; NVAF, non-valvular atrial fibrillation.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-170/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-170/coif). C.E. received honoraria for lectures from AstraZeneca, Novartis, Bayer, Boehringer Ingelheim, Daiichi Sankyo, Pfizer, outside the submitted work. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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