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Visceral fat index/percentage body fat ratio is independently associated with proximal aortic dilatation in a middle-aged and aged Chinese population in Liujiang of Guangxi

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ABSTRACT

Background and aims: Increased volume of visceral adipose tissue is associated with worsening of cardiovascular disease risk factors that contribute to aortic dilatation. We investigated the effects of visceral fat index (VFI) and VFI/percentage body fat (PBF) ratio on proximal aortic size and proximal aortic dilatation (PAD), to assess whether excess visceral fat deposition is an independent risk factor for PAD.
Methods: 738 participants aged 35 years or more were included in this cross-sectional survey. The sizes of aortic valve annulus (AVA), sinuses of Valsalva (SV), sinotubular junction (STJ), and ascending aorta (AscAo) were measured by transthoracic ultrasound. Multivariate linear regression, binary logistic regression, Bayesian linear regression, and receiver operating characteristic curves were performed to clarify the effects of VFI and VFI/PBF ratio on PAD.
Results: There were 78 participants (10.6%) with PAD. VFI and VFI/PBF ratio in the population with PAD was significantly increased, compared to the population without PAD ($p < 0.001$). However, PBF was not significantly different between the two populations. VFI/PBF ratio was positively associated with sizes of AVA, SV, STJ, and AscAo ($p < 0.05$), and was independently related to PAD ($p < 0.05$). A 1-SD increment in VFI/PBF ratio was associated with 13.35-fold increased risk of PAD (odds ratio: 13.35, $p < 0.05$).
Conclusions: VFI/PBF ratio is independently associated with PAD. An increased proportion of visceral fat may contribute to PAD. VFI/PBF ratio calculation may be used for the preliminary identification of individuals at high risk of PAD in the Chinese population.

1. Introduction

Aortic size is an independent predictor of cardiovascular diseases (CVDs) [1], closely related to acute aortic syndromes [2,3]. It is now recognized that increased age, male, and hypertension are major risk factors for aortic dilatation [4,5]. Recently, some studies have indicated that obesity and metabolic syndrome also contribute to aortic dilatation [6,7], and some evidence has showed that an increased volume of visceral adipose tissue is associated with worsening of CVD risk factors, such as hypertension and metabolic syndrome [8–10]. However, the association between visceral fat level and aortic dilatation has rarely been studied.

More than one-third of the adults are overweight or obese in China [11]. The traditional adiposity measurements include body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHtR) [12]. However, these indices could not discriminate visceral adipose tissue and subcutaneous adipose tissue. Computed tomography (CT), magnetic resonance imaging (MRI), and dual energy X-ray absorptiometry are current reliable methods for measurement of visceral adipose tissue and subcutaneous adipose tissue [13–15], but they have apparent limitations, such as cost and radiation exposure. Visceral fat index (VFI) is a parameter for the

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evaluation of visceral fat level by multi-frequency bioelectrical impedance analysis, which is simple, non-invasive and accurate [16,17]. In this study, we investigated the effects of VFI and VFI/percentage body fat (PBF) ratio on proximal aortic sizes and proximal aortic dilatation (PAD) in the China Guangxi Liujiang population by a cross-sectional epidemiological survey, to clarify the association of visceral adipose tissue with PAD.

2. Materials and methods

2.1. Study population

The cross-sectional epidemiological survey was conducted in the rural area of Liujiang, Guangxi Zhuang Autonomous Region of China, in December 2013. It was part of the national survey on prevalence of hypertension, covering 31 provinces across China. The methods and design of this survey have been explained in details by Wang et al. [18]. To clarify the effects of VFI and VFI/percentage body fat (PBF) ratio on proximal aortic sizes and PAD, a randomly selected subsample of 1000 subjects aged 35 years or more were invited to participate, and 889 were included in this survey. Participants with moderate to severe aortic/mitral stenosis and/or regurgitation, or with congenital heart disease were excluded. All the participants gave a written informed consent. The protocol was conducted under the Helsinki Declaration and was approved by the Ethical Committee of the Chinese Ministry of Science and Technology.

2.2. Aortic size measurement

Echocardiographic examinations were performed using the Sonos 5500 ultrasound system (Philips Medical Systems, Andover, MA) equipped with the appropriate two-dimensional transthoracic probe. The proximal aortic sizes were measured using the leading edge—to—leading edge convention at end-diastole. The following sites were included: (1) aortic valve annulus (AVA); (2) sinuses of Valsalva (SV); (3) sinotubular junction (STJ); (4) proximal ascending aorta at a level of 2 cm above the STJ (AscAo). All measurements were performed in the parasternal view, perpendicular to the long axis of the aorta. All measurements were performed by 2 trained technicians according to the American Society of Echocardiography guidelines [19]. An echocardiologist was responsible for quality control.

2.3. Assessments of risk factors and VFI

All participants were given standardized questionnaires, to obtain information on demographics, smoking history, alcohol use, medical history (such as hypertension, dyslipidemia, diabetes, stroke, coronary heart disease), and family history.

Participants were kept in fasting condition before the investigation. PBF and VFI were used to evaluate the overall obesity degree and visceral fat level, respectively. VFI/PBF ratio was used to evaluate the proportion of visceral fat. VFI/PBF ratio was calculated as VFI/PBF(%). Standard measurements for weight, PBF, and VFI were determined by bioelectrical impedance analysis, using Omron body composition monitor (V-body HBF-371, OMRON, Kyoto, Japan).

Height was measured to the nearest 0.1 cm, with a standard stadiometer. WC was measured to the nearest 0.1 cm, midway between the lowest rib and the superior border of the iliac crest, with a flexible anthropometric tape. WHtR was calculated as WC/height. BMI was calculated as weight/height^2. Body surface area (BSA) was calculated as $0.007184 \times \text{weight}^{0.425} \times \text{height}^{0.725}$ [20].

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were standardly measured three times or more in the seated position with the OMRON Professional PorTable Blood Pressure Monitor (HBP-1300, OMRON, Kyoto, Japan), after at least 5 min of rest. In 2% of the present samples, SBP and DBP were measured using both the OMRON device and a mercury sphygmomanometer (Yutu, Shanghai Medical Instruments Co., Ltd., Shanghai, China) for calibration. Measurements were repeated if there was a gap greater than 4 mmHg between SBP or DBP values with the mercury sphygmomanometer or 10 mmHg with the oscillometric BP monitor. The mean of the 3 closest values of SBP or DBP was used. Pulse pressure (PP) was calculated as SBP-DBP. Pulse rate was measured three times by palpating the radial pulse for 30 s after resting for 5 min. The mean of the three values of pulse rate was used.

Brachial and ankle blood pressures were simultaneously measured three times or more in supine position with WatchBP OFFICE ABI (MICROLIFE, Taiwan, China), after at least 10 min of rest. Measurements were repeated if there was a gap greater than 10 mmHg between SBP or DBP values. The means of the 3 closest values of SBP or DBP were used. Left or right ankle brachial index (ABI) was calculated as left ankle SBP/left brachial SBP or right ankle SBP/right brachial SBP. All the data was collected by trained postgraduates and a single supervisor was responsible for the quality control.

In addition, blood samples were obtained after a 12 h fast for measurements of total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglyceride (TG), fasting blood glucose (FBG), and serum creatinine (Scr). Measurements of blood samples were performed by trained technicians in ADICON CLINICAL LABORATORIES (Beijing, China).

2.4. Definitions

Hypertension was defined as SBP$\geq$140 mmHg and/or DBP$\geq$90 mmHg, or use of antihypertensive medications [21]. Diabetes was defined as fasting plasma glucose $\geq$7.0 mmol/L, or use of hypoglycemic medications [22]. Dyslipidemia was defined as TC $\geq$ 6.22 mmol/L, LDL-C $\geq$ 4.14 mmol/L, TG $\geq$ 2.26 mmol/L, and/or HDL-C $\leq$1.04 mmol/L [23]. PAD was defined as diameter at the level of the SV or AscAo $\geq$38 mm in men and $\geq$36 mm in women [24,25].

2.5. Statistical analysis

The continuous data are presented as mean $\pm$ standard deviation (SD). The discrete data are shown as percentages. The continuous variables between 2 groups were analyzed by the unpaired Student *t*-test or Mann-Whitney *U* test. The Discrete variables between 2 groups were analyzed by Chi-square test. Pearson correlation coefficients were used to assess simple correlations between risk factors and proximal aortic sizes, and Spearman's rank correlation coefficients were used to assess simple correlations between risk factors and PAD. The risk factors included VFI, PBF, VFI/PBF ratio, age, gender, smoking, BSA, BMI, WC, WHtR, SBP, DBP, PP, pulse rate, FBG, TC, TG, LDL-C, HDL-C, Scr, and ABI. Multivariate linear regression was performed to identify the effects of VFI and VFI/PBF ratio on proximal aortic sizes, adjusting for the risk factors. Before conducting the multivariate linear regression, a diagnosis for multicollinearity among covariates was assessed. The independent variables and odds ratios (ORs) for PAD were obtained from binary logistic regression model, adjusting for the candidate risk factors identified in Spearman's rank correlation analysis (the corresponding *p*-value was <0.05). C statistic was performed to assess model discrimination [26]. For model validation, 1000 bootstrap samples were used to derive a validation C statistic that would correct for potential model overfitting [26]. Besides, Bayesian linear regression was implemented to testify the