ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Relationship Between Waist-to-Neck Circumference Ratio and Coronary Artery Calcium Score

Bel Boyun Çevresi Oranı ve Koroner Kalsiyum Skoru Arasındaki İlişki

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ABSTRACT

Aim: *Coronary artery calcium score (CACS) is the leading parameter for detecting subclinical atherosclerosis. The waist-to-neck circumference ratio (WNR) is advantageous in determining visceral fat levels associated with atherosclerosis. In light of these findings, our study aimed to investigate the relationship between CACS and WNR.*

Material and Method: *We conducted a cross-sectional study at a single center as part of our research. The study consists of 362 patients who visited the cardiology outpatient clinic from March to May 2024. They underwent multidetector coronary computed tomography and had their CACS calculated. After obtaining written consent from the patients, past disease histories, waist circumference, neck circumference, blood pressure, and laboratory parameters were recorded. Waist-to-neck circumference ratio was calculated. Patients were divided into two groups: CACS=0 and CACS >0.*

Results: *Of all the patients, 70.7% (256 patients) had a CACS score of 0, with the remaining 29.3% (106 patients) having a CACS score greater than. The mean age in the group with CACS >0 was 52.85±8.79 years, and the mean age was statistically significantly higher (p<0.001). Waist-to-neck circumference ratio was statistically significantly higher in the group with CACS >0 (p<0.001). In logistic regression analyses, WNR emerged as a significant independent predictor of detecting the presence of CACS (p=0.001). The Receiver operating characteristic curve (ROC) analysis was performed to evaluate the ability of WNR to predict the presence of CACS, the area under the curve was determined as 0.665 (0.604–725), the cut-off was 2.75, the sensitivity was 67.9%, and the specificity was 67.2% (p<0.001).*

Conclusion: *Our study found a significant relationship between WNR and the presence of CACS.*

Key words: *anthropometric measurements; atherosclerosis; waist-neck circumference ratio; coronary artery calcium score*

ÖZET

Amaç: *Koroner arter kalsiyum skoru (KAKS) subklinik ateroskleroz tespiti için en önde gelen parametredir. Bel boyun çevresi oranı (BBÇO) içerdiği parametreler sebebiyle visseral yağlanmayı tahmin etmek için kullanılabilir. Visseral yağlanma ateroskleroz ile ilişkilidir. Bu bulgular ışığında çalışmamız KAKS ile BBÇO arasındaki ilişkiyi araştırmayı amaçlamıştır.*

Materyal ve Metod: *Çalışmamız tek merkez kesitsel çalışma olarak tasarlanmıştır. Mart-Mayıs 2024 tarihleri arasında kardiyojoji polikliniğine başvuran multidedektör koroner bilgisayarlı tomografi çekilen ve KAKS hesaplanmış 362 hastayı kapsamaktadır. Hastalardan yazılı onam alındıktan sonra geçmiş hastalık öyküleri, bel çevresi, boyun çevresi, kan basıncı ve laboratuvar parametreleri kaydedildi. Bel boyun çevresi oranı hesaplandı. Hastalar KAKS=0 ve KAKS >0 olan olarak iki gruba ayrıldı.*

Bulgular: *Hastaların %70,7'sinde (256 hasta) KAKS=0 iken, %29,3'ünde (106 hasta) KAKS >0 olarak değerlendirildi. Koroner arter kalsiyum skoru >0 olan grupta yaş ortalaması 52,85±8,79 yıldı ve bu grupta yaş ortalaması istatistiksel olarak anlamlı daha yüksekti (p<0,001). Bel boyun çevresi oranı KAKS >0 olan grupta istatistiksel olarak anlamlı daha yüksekti (p<0,001). Yapılan tek değişkenli ve çok değişkenli lojistik regresyon analizinde BBÇO'nun KAKS varlığı tespitinde bağımsız bir öngördürücü olduğu bulundu (p=0,001). BBÇO'nun KAKS varlığını tahmin etme yeteneğini değerlendirmek için yapılan ROC analizinde eğri altında kalan alan 0.665 (0,604–725), cut-off 2,75, sensitivite %67,9 ve spesifite %67,2 olarak belirlendi (p<0,001).*

Sonuç: *Çalışmamız BBÇO ve KAKS varlığını arasında anlamlı bir ilişki olduğunu göstermiştir.*

Anahtar Kelimeler: *antropometrik ölçümler; ateroskleroz; bel boyun çevresi oranı; koroner arter kalsiyum skoru*

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Introduction

Cardiovascular diseases are one of the leading causes of death worldwide. Atherosclerosis is one of the most significant causes of cardiovascular diseases. It is crucial to detect and treat atherosclerosis early. One of the main non-invasive tests used to detect atherosclerosis is multidetector coronary tomography (MDCT) and coronary artery calcium score (CACS) calculated via MDCT[1]. Coronary artery calcium score is a good tool for detecting atherosclerosis and assessing the risk of developing adverse cardiovascular events[2]. However, the disadvantages of the examination are the allergic reaction caused by the contrast material applied during MDCT imaging, the risk of contrast nephropathy that may develop afterward, and the expense of the examination[3]. These examination disadvantages emphasize the need for alternative diagnostic tools to detect the presence of atherosclerosis and CACS.

Anthropometric measurements like waist circumference (WC), neck circumference (NC), and body mass index (BMI) can help in detecting visceral obesity[4]. Recent studies suggest that the fat tissue in the upper body may produce inflammatory cytokines, leading to insulin resistance and a higher risk of cardiovascular disease. The fact that visceral obesity is associated with atherosclerosis and major adverse cardiac events makes this situation important[5]. The waist-to-neck circumference ratio (WNR) is a possible marker for sleep apnea in children, connected to body fat distribution and obesity[6]. Considering the association of upper body fat distribution with cardiovascular disease risk and obesity, our study aimed to evaluate the relationship between WNR and CACS.

Materials and Methods

Study Design and Patient Selection

The format of this study was a cross-sectional, single-center study. This study included 362 patients who applied to the cardiology outpatient clinic of our center between March and May 2024 and underwent MDCT during non-invasive tests performed to evaluate chest pain of cardiac origin. We obtained written consent from the admitted patients and recorded their previous history, systolic and diastolic blood pressures, age, gender information, hemogram, biochemical parameters, and WC, NC, and BMI information. Coronary artery calcium score was obtained and recorded from MDCT reports. Waist-to-neck circumference ratio was calculated by dividing WC by NC. Excluded from the study were patients with coronary artery disease, malignancies, chronic inflammatory diseases, Cushing's syndrome, those who had undergone bariatric surgery, individuals with goiter and spine anomalies affecting neck circumference, and patients with severe liver and kidney failure. This study was performed by the Declaration of Helsinki and with the approval of the local ethics committee.

Measurement of Laboratory Parameters

Venous blood was collected from participants following an 8–12 hour fast. Using electrical impedance, hemoglobin, hematocrit, platelet, and white blood cell counts were determined. Biochemical parameters were analyzed using standard laboratory methods (Beckman Coulter LH 780, Miami, FL, ABD). Total cholesterol, triglyceride, and high-density lipoprotein levels were determined utilizing the Beckman Coulter AU5800 analytical platform. The calculation of low-density lipoprotein levels involved the Friedewald equation.

Blood Pressure and Anthropometric Measurements

The blood pressure was measured using a sphygmomanometer. There was an assurance that no cigarettes or caffeine had been consumed 30 minutes before the measurement. The cardiologist took the measurement following a minimum 5-minute rest period. Individuals without a hypertension (HT) diagnosis had their blood pressure measured in both arms, with the highest reading recorded.

Weight and height values were documented to compute BMI. The scale is in kilograms for weight and centimeters for height. Body mass index equals weight divided by height squared.

For NC measurement, the patient was seated upright and facing forward. Female patients had their midpoint measured between the upper neck and upper sternum, while male patients had their measurement taken below the laryngeal prominence.

For WC measurement, the patient was standing upright with the patient's legs shoulder-width apart, and the measurement was based on the midpoint between the lowest rib and the spina iliaca anterior superior.

Coronary Artery Calcium Score Measurement

The CACS was determined using an MDCT scan and calculated using the modified Agatston protocol 7. The same radiology specialist examined the MDCT results. Coronary artery calcium score progression is recognized when the CACS shows a measurement greater than zero.

Statistical Analysis

Numbers and percentages were used to represent categorical data. Nonparametric data was analyzed using the χ^2 test. We examined the normality of all variables by conducting the Kolmogorov–Smirnov test and examined the homogeneity of variances with the Levene test before conducting significance tests. T-tests for independent groups were used to analyze data that showed a normal distribution and homogeneity. The Mann-Whitney U test was used to evaluate differences between parameters that did not show normal distribution between two groups, while comparisons between more than two groups were performed by analysis of variance or Kruskal-Wallis tests. The relationships between quantitative variables were evaluated using the Spearman correlation test. Univariate and multivariate logistic regression was performed to analyze the defined risk factors for CACS progression and determine independent risk factors. All analyses were performed using the IBM Statistical Package for Social Sciences (SPSS) program version 23.0 (IBM Corp., NY, USA) statistical package. For all statistical analyses, the significance level was deemed to be two-sided, p <0.05.

Results

Our study included 362 patients who applied to our center's cardiology outpatient clinic and underwent MDCT between March and May 2024. Patients were categorized into two groups based on their coronary artery calcium score (CACS): one group had a CACS of 0, while the other group had a CACS >0 (there is CACS progression). Of all the patients, 70.7% (256 patients) had a CACS score of 0, with the remaining 29.3% (106 patients) having a CACS score greater than. Although there were more female participants in the group with CACS >0, there was no statistically significant difference in terms of gender between the groups. The mean age in the group with CACS >0 was 52.85±8.79 years, and the mean age was statistically significantly higher (p<0.001). In the group where CACS >0 occurred, the prevalence of HT was 37.7% (40 patients), compared to 25% (64 patients) in the group with CACS=0 (p=0.015). Platelet levels were significantly lower in the group with CACS >0 (p=0.008). Glucose, alanine aminotransferase (ALT), and creatinine were statistically significantly higher in the group with CACS >0 (p=0.03, p<0.001, and p=0.008, respectively). BMI, weight, WC, Systolic blood pressure (SBP), and WNR were statistically significantly higher in the group with CACS >0 (p<0.001, p<0.001, p<0.001, p=0.013, and p<0.001, respectively). Review Table 1 for the details.

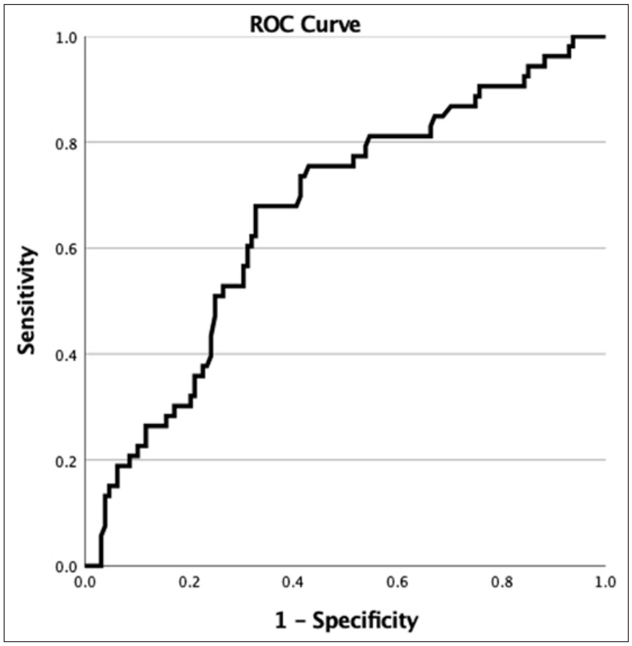

Figure 1. *Receiver operating characteristic curve (ROC) analysis.*

A univariate and multivariate logistic regression analysis was performed to identify independent factors associated with detecting the presence of CACS. Age, platelet count, ALT levels, and WNR were all independent predictors of the presence of CACS (p=0.001, p=0.004, p=0.002, and p=0.001, respectively). The results of the regression analysis are detailed in Table 2.

Receiver operating characteristic curve analysis was performed to evaluate the ability of WNR to predict the presence of CACS. As a result of the analysis, the area under the curve (AUC) was determined as 0.665 (0.604–725), the cut-off was 2.75, the sensitivity was 67.9%, and the specificity was 67.2% (p<0.001) (Figure 1).

Table 1. *Baseline demographic characteristics*

Variables	Coronary calcium score=0 (n=256)	Coronary calcium score >0 (n=106)	P value
Gender, male (%)	110 (43)	40 (37.7)	0.358
Age (years)	46.48±11.67	52.85±8.79	**<0.001**
Height (cm)	167.14±8.59	167.26±9.74	0.466
BMI (kg/m²)	28.40±5.41	30.13±5.11	**<0.001**
Weight (kg)	79.24±15.39	84.02±14.23	**<0.001**
NC (cm)	35.46±3.86	36.22±3.46	0.281
WC (cm)	95.5±13.4	104.35±13.90	**<0.001**
CVE, n (%)	4 (1.6)	4 (3.8)	0.193
HF, n (%)	6 (2.3)	0 (0.0)	0.112
COPD, n (%)	6 (2.3)	4 (3.8)	0.450
HT, n (%)	64 (25)	40 (37.7)	**0.015**
DM, n (%)	22 (8.6)	8 (7.5)	0.742
SBP (mmHg)	128.49±16.73	133.34±19.25	**0.013**
DBP (mmHg)	74.96±10.22	77.75±12.29	0.055
WBC (10³/μL)	9.22 (7.8–10.91)	8.84 (7.16–11.05)	0.226
Hemoglobin (g/dL)	15.46±1.69	15.79±1.51	0.269
Platelet (10³/μL)	296 (242–348)	265 (236–338)	**0.008**
CRP (mg/L)	3 (1.07–7.84)	4.40 (1.72–10)	0.199
Glucose (mg/dL)	92 (85–97)	94 (89–98)	0.03
ALT (U/L)	27 (19–37)	33 (22–43)	**<0.001**
Total Cholesterol (mg/dL)	187.62±40.28	194.84±63.10	0.701
HDL (mg/dL)	44.32±11.53	43.17±10.08	0.319
LDL (mg/dL)	129 (98–148)	126 (92–150)	0.626
Triglyceride (mg/dL)	167 (95–237)	171(86–265)	0.563
Creatinine (mg/dL)	0.88±0.19	0.92±0.18	**0.008**
HbA1C (%)	5.7 (5.38–6.15)	5.8 (5.35–6.28)	0.924
Calcium (mg/dl)	9.52±0.65	9.6±0.52	0.341
WNR	2.70±0.35	2.88±0.34	**<0.001**

BMI: body mass index; NC: neck circumference; WC: waist circumference; CVE: cerebrovascular event; HF: heart failure; COPD: chronic obstructive pulmonary disease; HT: hypertension; DM: diabetes mellitus; SBP: systolic blood pressure; DBP: diastolic blood pressure; WBC: white blood cells; CRP: C-reactive protein; ALT: alanine aminotransferase; HDL: high-density lipoprotein; LDL: low-density lipoprotein; WNR: waist-to-neck circumference ratio.

Table 2. *Univariate and multivariate logistic regression analysis*

Variables	Univariate OR (95% CI)	P value	Multivariate OR (95% CI)	P value
Age	1.057 (1.033–1.081)	**<0.001**	1.043 (1.017–1.071)	**0.001**
BMI	1.061 (1.017–1.108)	**0.006**	1.005 (0.951–1.063)	0.852
SBP	1.016 (1.003–1.029)	**0.018**	1.005 (0.990–1.021)	0.508
Platelet	0.996 (0.993–0.999)	**0.004**	0.995 (0.992–0.998)	**0.004**
Glucose	1.000 (0.996–1.003)	0.918	0.998 (0.993–1.002)	0.357
ALT	1.021 (1.009–1.033)	**<0.001**	1.022 (1.008–1.036)	**0.002**
Creatinine	4.184 (1.294–13.530)	**0.017**	2.326 (0.636–8.501)	0.202
WNR	4.003 (2.101–7.626)	**<0.001**	4.054 (1.744–9.424)	**0.001**

BMI: body mass index; SBP: systolic blood pressure; ALT: alanine aminotransferase; WNR: waist-to-neck circumference ratio; OR: odds ratio; CI: confidence interval.

Discussion

Our study found a significant relationship between WNR and the presence of CACS. Waist-to-neck circumference ratio is a simple parameter to utilize, and to our knowledge, our study is the first to evaluate this relationship.

Subclinical atherosclerosis is a condition that can cause individuals to experience adverse cardiovascular events[8]. Detection and early treatment of this condition may contribute positively to the patient's morbidity and mortality[9]. Multidetector coronary tomography and CACS are crucial diagnostic tools for identifying subclinical coronary atherosclerosis. Not only is CACS related to adverse cardiovascular outcomes, but it also shows a strong association with visceral adiposity[10]. Additionally, adverse cardiovascular events were associated with CACS and visceral adiposity[11,12]. Waist circumference, NC, and BMI have previously been used to detect visceral adiposity[13,14]. Implementing alternative, non-invasive anthropometric measurements in assessing subclinical atherosclerosis could be advantageous, particularly in light of the radiation exposure, contrast material complications, lengthy procedure time, and cost of using MDCT for CACS calculation. With this feature, our study emphasized the importance of anthropometric measurements.

Body mass index indicates general obesity. However, it may cause abdominal obesity to be overlooked. While general and abdominal obesity are typically correlated, some individuals have a normal BMI but high WC measurements[15,16]. Waist circumference alone may be an indicator of coronary artery disease. Some studies have even defined it as a better parameter than BMI in detecting coronary artery disease. Because even if the individual has a normal BMI, a higher waist circumference still poses a risk for cardiovascular diseases[17]. Recent advancements in imaging techniques have led to investigations on the detection of subcutaneous, intra-abdominal, and visceral adipose tissues and their association with cardiovascular diseases[18]. There is a hypothesis that inflammatory cytokines released from particular fatty areas may be involved in the pathogenesis of atherosclerotic heart disease [5]. This indicates that WC could be a more dependable indicator than BMI when evaluating the likelihood of cardiovascular disease. Our study revealed that patients with CACS >0 had significantly higher WC, similar to the literature.

In recent studies, NC is closely associated with diseases such as metabolic syndrome and metabolic parameters such as BMI, blood lipid panel, and fasting blood glucose[19,20]. However, there are conflicting findings regarding the relationship of NC with cardiovascular diseases and CACS. In a study conducted in China on elderly patients with acute coronary syndrome, there was a relationship between NC and angiographically measured CACS[21]. On the other hand, a multicenter study from 2016 revealed a relationship between NC and carotid artery intima-media thickness but did not find any association with CACS[22]. In our study, NC did not show a statistically significant difference in the groups with CACS=0 and CACS >0. This situation was similar to some studies in the literature.

Waist-to-neck circumference ratio may be a valuable and easily applicable potential parameter because it represents WC and NC, which can indicate visceral obesity. In our study, both groups were similar in terms of gender representation. Gender plays a role in determining the limits of WC in metabolic syndrome. However, in our study, determining the WNR cut-off value as a single value for both genders may provide clinical convenience.

In our study, low platelet levels, advanced age, and high ALT levels were also statistically and significantly associated with CACS. Our risk of atherosclerotic heart disease increases with aging. There is also a positive correlation between age and CACS. The reason for this could be the advancement of atherosclerosis, heightened inflammation, and deterioration of the vascular system as one ages[23]. In our study, age was statistically significantly associated with CACS, consistent with the literature. Alanine aminotransferase is a parameter that shows hepatic functions. A study revealed a connection between increased ALT levels and atherosclerosis, CACS, and hepatic steatosis, whether liver disease was present or not. The association between hepatic steatosis and atherosclerosis explains this situation. Also, there may be a connection between inflammation and oxidative stress related to elevated ALT levels and the presence of CACS[24]. To our knowledge, there is limited data in the literature investigating the relationship between platelet count and CACS. However, in a study examining the relationship between mean platelet volume and CACS, patients with CACS showed lower platelet levels[25]. Once again, this might be because of the impact of oxidative stress and inflammatory mediators on blood cells, like platelets.

Our study had several limitations. Although it was designed cross-sectionally, the number of patients included was relatively small. The patients included in the study were relatively young. The patients' metabolic parameters, such as blood pressure and lipid panel, were closer to normal. Future studies with a larger patient sample size could enhance the significance of this issue even more.

Conclusion

Our study found a significant relationship between WNR and the presence of CACS, which plays a crucial role in detecting subclinical atherosclerosis. Given the high expenses, lengthy procedure, and potential risks associated with radiation and contrast in MDCT, employing a cost-effective and straightforward measure like WNR to estimate CACS could offer clinical benefits.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest regarding this article's research, authorship, and/or publication.

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Informed consent

Informed consent was obtained from all participants in the study.

Ethical Approval

This study was approved by the Atatürk University Ethical Committee (Protocol Number 29.03.2024-B. 30.2.ATA.0.01.00/199).

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