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Original Article

# Usability of aortic knob width as novel clinical predictor for coronary artery disease severity before elective coronary angiography

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**Abstract**

**Aim:** In this study, we aimed to investigate the relationship between AKW and the severity of CAD in patients with stable CAD. Stable coronary artery disease (CAD) patients coronary artery disease severity is determined invasive coronary angiography scoring systems as SYNTAX and Gensini scores. Therefore, there is a need for noninvasive and easy to apply methods for determining the severity of the disease in stable CAD. Aortic knob width (AKW) is a measurable radiographic structure from chest X-ray.

**Material and Methods:** The study included 168 patients with stable CAD ranging from 18 to 70 years old after exclusions criteria applied 114 patients examined. Patients grouped according to coronary artery vessel diameter narrowing above and below 70%. Patients Baseline characteristics, physical examination, medical treatments and laboratory findings recorded. The severity of CAD was evaluated by SYNTAX and Gensini scores. AKW measurement was also evaluated.

**Results:** The two groups were statistically similar with respect to demographic properties and laboratory findings. Prior medications were similar between the groups. Furthermore percentage of diabetes mellitus and CRP levels were significantly different between groups (48.4%, 22% p:0.004 , 6.3±12, 2.4±4 p:0.049 respectively). AKW was significantly higher in group 1 compared to group 2 (41.1±6.2, 37.3±5.2; p=0.007). AKWs were correlated with Gensini and SYNTAX scores (r=0.25;p=0.007 and r=0.26;p=0.006 respectively). In a ROC analysis, the area under the curve value of AKW for CAD was 0.648 (95% CI: 0.544-0.752, p<0.008). The optimal cut-off value of AKW measurement for CAD was 36.6 mm with 73% sensitivity and 61% specificity. In a multivariate analysis, independent predictors for SYNTAX score > 22 were; DM (Odds ratio [OR]: 6,088, 95% CI: 1.617-22.927; P= 0.008) , AKW (OR: 1.122, 95% CI: 1.024-1.229;P= 0.013).

**Conclusion:** To demonstrate the severity and complexity of coronary artery disease in stable coronary artery disease, noninvasive and simply calculated AKW can be used instead of invasively calculated the calculated SYNTAX and Gensini scores.

**Keywords:** Aortic knob width; coronary artery disease severity; SYNTAX Score

## INTRODUCTION

Cardiovascular diseases are one of the common and leading causes of mortality in the community. Events like stroke, myocardial infarction and peripheral artery diseases evolve secondary to the progression of atherosclerosis. Atherosclerosis is a systemic disease that progresses with accumulation of lipid and inflammatory cells in the arterial wall. Thickening of the vessel wall shows itself as a plaque formation and the artery lumen gradually begin to narrow down by plaques (1). Stable coronary artery disease (CAD) occurs when narrowing plaques in the coronary arteries restrict the oxygen delivery during exercise. Stable coronary artery disease patients with outpatient referrals are evaluated by examinations such as exercise electrocardiography, myocardial perfusion scintigraphy (MPS) and stress echocardiography to determine the risk status. Positive test resulted patients are referred to coronary artery angiography (CAA) after evaluation. In CAA severity of CAD is determined by such scoring systems as SYNTAX (Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery) and Gensini scores, and the needed interventional procedures are planned according to these scores. Chest X-rays are performed to exclude thoracic pathologies in nearly all patients with angina pectoris. Although chest radiography is a simple method of examination, it can give the clinician an idea of many issues. Important evaluations may be performed about cardiothoracic ratio, heart chambers, ascending aorta,

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abdominal aorta, pulmonary arteries, vena caves and pericardium. The dilatation of the ascending aorta, aortic arch and calcifications are stimulating the attention of the clinician prior to coronary angiography for embolization of the calcific plaques and about catheters that will be used during the procedure. Aortic knob width (AKW) is a measurable radiographic structure from the edge of the descending aorta to the lateral border of the trachea wall (2).

As far as the researchers of this study investigated, there is no study in the literature evaluating the association of AKW and CAD grade and complexity in stable coronary artery patients. In this study, we aimed to investigate the relationship between AKW and the severity of CAD which was calculated by SYNTAX and Gensini scores in patients with stable CAD.

## MATERIAL and METHODS

**Study Population**

The study included 168 patients with stable CAD ranging from 18 to 70 years old. These patients referred to our outpatient clinic in the time period between October and November 2018. They were diagnosed with ischemia in the exercise stress electrocardiography or myocardial perfusion scintigraphy. Patients with ischemia who were directed to coronary angiography included in study population. Patients with history of previous coronary artery bypass surgery, history of coronary artery interventional procedures, heart failure (EF<50%), abnormal kidney function, diabetes mellitus with end organ damage, uncontrolled hypertension, cerebrovascular disease, ascending aortic aneurysm, and those with known aortic vessel disease and medicated with corticosteroids were excluded from study. In addition, patients with non-optimal and non-centered chest X-ray radiography, tracheal shift, and those who had a history of thoracic surgery for any reason were excluded from study. Clinical history was obtained from all patients and physical examinations were performed. We have total 168 subjects, after applying exclusion criteria 54 were excluded and the remaining 114 ones were examined in the study. The severity of CAD was calculated in coronary angiography in 114 patients following the exclusion criteria by both of SYNTAX and Gensini scores. Patients were grouped as group 1 and group 2 according to the coronary artery vessel lumen diameter narrowing above or below 70% documented in coronary angiography. All participants provided written informed consent prior to inclusion. Local ethical committee approved study in 24.5.2019 date and 1854 decision number.

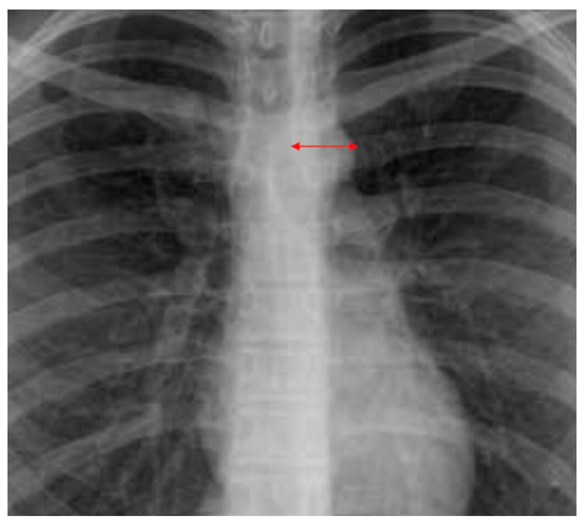
**Coronary Angiography**

Coronary angiography was performed according to the standard Judkins's method, via femoral artery puncture with a monoplan coronary angiography device (Siemens, Artis zee, Erlangen, Germany). Four major coronary artery branches (left main, left anterior descending, left circumflex, and right coronary artery) were evaluated from different angiographic views and the lesions with more than 70% stenosis were determined as significant stenosis. All the angiograms were evaluated by an experienced interventional cardiologist who was blinded to the clinical and laboratory data.

We used SYNTAX score to calculate CAD complexity. The SYNTAX score includes bifurcation lesions, trifurcation lesions, calcification, tortuosity, thrombus, and occlusion duration parameters to calculate the complexity of CAD. In vessels ≥1.5 mm in lumen diameter with luminal stenosis >50% is separately scored (6). The SYNTAX scores of the patients were calculated using the latest updated version of the calculator available at http://www.syntaxscore.com. Gensini score is a scoring system which is graded according to the importance of topographic localization of vessel with luminal narrowing degree in coronary arteries Gensini score grades narrowing of the lumen as follows: 1, 1%–25% narrowing; 2, 26%–50% occlusion; 4, 51%–75% narrowing; 8, 76%–90% narrowing; 16, 91%–99% narrowing; and 32, total occlusion. This score is multiplied by the importance of the lesion position in the coronary arterial tree (5 for left main, 2.5 for proximal left coronary artery, and 1 for proximal right coronary artery (7).

**Aortic knob width (AKW) Measurement**

A researcher blinded to the coronary angiography results of the patients reviewed the chest radiographies. The AKW was measured along with the widest point of the ascending aortic knob from the point of the tracheas lateral edge to the aortic knob's left lateral wall. Calcification in the aortic knob was also noted (Figure 1) (2).



**Figur 1.** Measurement of Aortic Knob Width

**Laboratory Tests**

The patients' blood pressure, smoking status, weight, height and medications were recorded. All patients underwent laboratory tests using standard methods; venous blood samples were obtained after fasting overnight. Renal function tests, liver function tests, lipid profiles, blood count and C-reactive protein (CRP) levels were also measured.

**Statistical Analysis**

All statistical analyses were carried out using SPSS for Windows 13.0. The Kolmogorov-Smirnov test was used to test the normality of distribution of quantitative data. Descriptive statistics for numerical variables were expressed as mean±SD, while categorical data were reported as n (%). The Chi-square test and Fisher's Exact test were used to compare categorical variables between the groups. The comparison of continuous variables between the control and critical CAD groups was performed by the independent sample test when the assumptions of parametric test assumptions were met and by Mann-Whitney U test when the assumptions of parametric test assumptions were not met. Correlation analyzes were calculated using Pearson's or Spearman's correlation tests. To assess the independent contribution of each variable, we performed a multiple logistic regression analysis that included all clinical variables with a $p < 0.05$ in the univariate analysis. The odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. A receiver operating characteristic (ROC) curve analysis was used to calculate the AKW value that predicted CAD with the best specificity and sensitivity. A p-value of <0.05 indicated statistical significance.

## RESULTS

The two groups were statistically similar with respect to demographic properties; and age (62.98±10.27, 58.21±10.47; P :0.192, respectively), gender, height, weight, body mass index (BMI), history of hyperlipidemia,

history of hypertension and smoking were insignificant between the groups. Also, the history of diabetes mellitus was significantly higher in group 1 compared to group 2(48.4%, 22% p:0.004, respectively). Systolic-diastolic blood pressures were also similar between the groups (Table 1). Although the vast majority of the urea levels and heart rate were between the normal ranges, the values were significantly higher in group 1compared togroup 2 (43.7±23.3, 35.5±12.7 p:0.039, 78.2±15.0 69.6±12.4 p:0.003 respectively). The levels of AST, ALT, creatinine and lipid panel measurements were similar between the groups. Prior medications ACE inhibitors and beta blockers were similar between the groups; dispite calcium channel blockers (CCB) medication was different. Furthermore, CRP measurements were significantly different between the groups (6.3±12 , 2.4±4 p:0.049 respectively) (Table 1).

AKW was significantly higher in group 1 compared to group 2 (41.1±6.2 vs. 37.3±5.2; p=0.007). AKWs were correlated with Gensini and SYNTAX scores (r=0.25; p=0.007 and r=0.26; p=0.006 respectively) (Table 2). In a receiver operating curve analysis , the area under the curve value of AKW measurement for CAD was 0.648( 95% CI: 0.544-0.752, p=0.008). The optimal cut-off value of AKW measurement for CAD was 36.6 mm with 73% sensitivity and 61% specificity (Figure 2).

After performing correlation analysis we grouped patients according to SYNTAX score above and below 22.

A multivariate logistic regression analysis was used to determine independent predictors in SYNTAX score >22 . we used parameters found to be associated with SYNTAX score above 22 in a univariate analysis (age, DM and AKW).

In a multivariate analysis, independent predictors for SYNTAX score > 22 were; DM (Odds ratio [OR]: 6.088, 95% CI: 1.617-22.927; P= 0.008) , AKW (OR: 1.122, 95% CI: 1.024-1.229; P= 0.013) and these variables were shown in Table 3.

**Table 1. Baseline characteristics, physical examination and medical treatment of all patients**

| | Group 1(n=76) | Group 2 (n=38) | P value |
|---|---|---|---|
| Age, years | 62.98 ± 10.27 | 58.21 ± 10.47 | 0.192 |
| Male, gender, n (%) | 41 (54%) | 23 (61%) | 0.635 |
| Hypertension, n (%) | 44 (58.8) | 17 (46.3) | 0.194 |
| Diabetes mellitus, n (%) | 36 (48.8) | 8 (22.0) | 0.004 |
| Hyperlipidemia, n (%) | 22 (30.0) | 12 (29.3) | 0.934 |
| Current smoking status, n (%) | 32 (41.3) | 16 (43.9) | 0.78 |
| Height, cm | 165.46 ± 9.05 | 166.86 ± 8.18 | 0.167 |
| Weight, kg | 80.75 ±14.43 | 78.10 ± 12.23 | 0.864 |
| Body mass index(kg/m$^2$) | 29.5 ± 5.3 | 28.9 ± 4.7 | 0.583 |
| Systolic blood pressure, mm Hg | 138.1± 23.1 | 135.5 ± 16.9 | 0.537 |
| Diastolic blood pressure, mm Hg | 75.6 ±13.8 | 72.7 ± 10.7 | 0.188 |
| Heart rate, beats per minute | 78.2 ±15 | 69.6 ± 12.4 | 0.003 |
| ACE inhibitor, n (%) | 28 (38.5) | 11 (29.3) | 0.319 |
| Beta-Blocker, n (%) | 26 (34.6) | 10 (26.8) | 0.387 |
| Calcium channel blocker, n (%) | 17 (23.3) | 3 (7.3) | 0.032 |

Continuous variables are presented as mean ± SD, Nominal variables presented as frequency (%)
ACE: Angiotensin Converting Enzyme

**Table 2. Laboratory, angiographic and radiological findings**

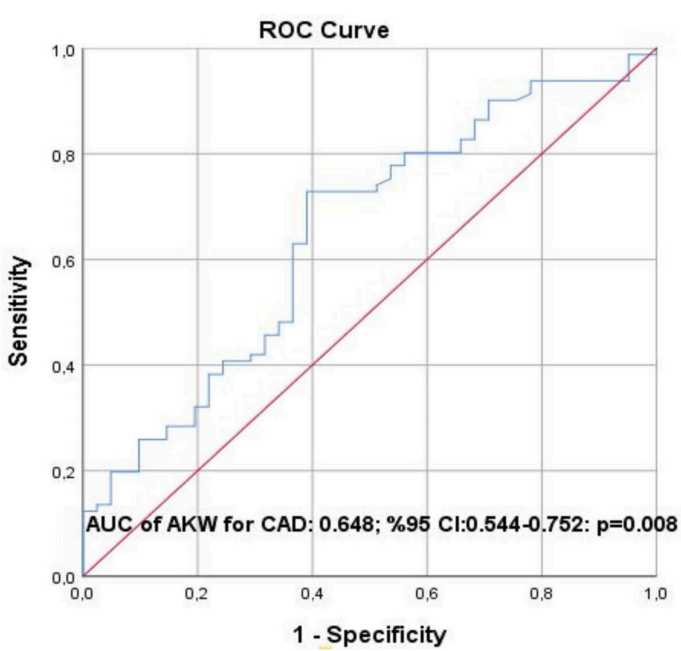
| | Group 1(n=76) | Group 2 (n=38) | P value |
|---|---|---|---|
| Blood urea nitrogen, mg/dL | 43.7 ± 23.3 | 35.5 ± 12.7 | 0.039 |
| Creatinine, mg/dL | 1.1 ± 0.94 | 0.84 ± 0.2 | 0.091 |
| ALT, U/L | 23.2 ± 26.7 | 25.7 ± 25.7 | 0.693 |
| AST, U/L | 32.5 ± 44.6 | 34.5 ± 53.4 | 0.831 |
| Total cholesterol (mg/dL) | 184.4 ± 54.8 | 198.9 ± 50.7 | 0.166 |
| Triglycerides (mg/dL) | 165.5 ± 97.2 | 138.3 ± 67.1 | 0.115 |
| High-density lipoprotein cholesterol (mmol/L) | 38.7 ± 10.3 | 43 ±10.9 | 0.04 |
| Low-density lipoprotein cholesterol (mmol/L) | 114.1 ± 44.9 | 125.9 ± 43.2 | 0.175 |
| C-reactive protein (mg/L) | 6.3 ± 12 | 2.4 ± 4 | 0.049 |
| Aortic knob width, mm | 40.4 ± 6.5 | 37.2 ± 5.1 | 0.007 |
| Syntax score | 15.8 ± 9.6 | 1.3 ± 2.5 | 0.001 |
| Gensini score | 49 ± 44.4 | 1.2 ± 2.6 | 0.001 |

Continuous variables are presented as mean ± SD, Nominal variables presented as frequency (%). ALT: Alanine Aminotransferase ; AST: Aspartate Aminotransferase; SYNTAX: Synergy Between PCI With Taxus and Cardiac Surgery

**Table 3. Uni-Multivariable logistic regression analysis for SYNTAX score>22**

| | Univariate | | | Multivariate | | |
|---|---|---|---|---|---|---|
| | OR | 95% CI | P value | OR | 95% CI | P value |
| DM | 5.271 | 1.516 - 18.328 | 0.009 | 6.088 | 1.617-22.927 | 0.008 |
| Age ( years) | 1.064 | 1.005 – 1.127 | 0.033 | | | |
| AKW (mm) | 1.110 | 1.019 – 1.209 | 0.016 | 1.122 | 1.024-1.229 | 0.013 |

AKW : Aortic Knob Width; DM: Diabetes Mellitus




**Figur 2.** Receiver Operating Curve Analysis

## DISCUSSION

The results of our study showed that; CAD severity, which is calculated by using both of SYNTAX and Gensini scores from coronary angiography in stable CAD, was significantly correlated with AKW measured from chest radiography.

CADs are one of the most common disease groups seen as a result of atherosclerosis. In order to determine the risk of CAD and to use it in clinical practice, many risk determination methods have been developed. For acute coronary syndromes such as Global Registry of Acute Coronary Events (GRACE) risk score, the Thrombolysis in Myocardial Infarction (TIMI) score, heart score and Diamond-Forrester score were developed (8,9).

In stable CAD patients pretest probability (PTP) estimate is currently used in the management. Variables entering the PTP estimation include the age, gender and characteristics of angına described as one of the following: non–anginal pain, atypical angına or typical angina. According to the guidelines on management of stable CAD patients, the event risk stratification should be performed whenever the estimated PTP is higher than 15%. Patients can be assessed by cardiac exercise stress test protocols after determination of being in moderate risk group (10). Patients with positive stress test results were refered to coronary artery angiography. However, despite this evaluation, CAD is not detected in the angiography of some patients with positive stress test results. Therefore, there is a need for further data to be used in the pre-procedure risk assessment in predicting CAD.

SYNTAX and Gensini scores are scoring systems which need an invasive coronary angiography method before calculating the extent and severity of CAD (11,12). Therefore, there is a need for noninvasive, cost effective, and easy to apply methods which do not require calculation for determining the complexity and severity of the disease in patients with stable CAD.

Fiero et al. showed the association of AKW with atherosclerosis, hypertension and age for the first time (13). Rayner et al. showed that AKW increased in hypertensive patients and was associated with left ventricular hypertrophy (14). Factors related to cardiovascular events such as heart rate variability were also shown to be associated with the AKW (15). Yun et al. showed that AKW and calcification were associated with the severity and complexity of CAD in patients with acute coronary syndromes (16). Accordingly, it can be suggested that peripheral measurements like AKW are associated with CAD severity.

We observed that the severity of CAD calculated by invasive methods such as SYNTAX and Gensini scores in stable CAD patients is closely related to AKW measurement. Therefore, AKW can provide significant predictive information about the severity and complexity of CAD in patients with stable CAD. To our knowledge, there is no study evaluating the association of AKW and CAD severity in stable CAD patients. AKW is an easily accessible and cheap measurement method and may be useful for the prediction of CAD severity in clinical practices.

## LIMITATIONS

For applicability of this model, further research on larger sample sizes and different populations is required. Study can be performed in acute coronary syndromes with larger sample sizes.

## CONCLUSION

To demonstrate the severity and complexity of coronary artery disease in stable coronary artery disease, noninvasive and simply calculated AKW can be used instead of invasively calculated the calculated SYNTAX and Gensini scores.

*Competing interests: The authors declare that they have no competing interest.*

*Financial Disclosure: There are no financial supports.*

*Ethical approval: Local ethical committee approved study in Istanbul Education and Research Hospital 24.5.2019 date and 1854 decision number.*

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