Evaluation of Subclinical Atherosclerosis Using Ultrasound Radiofrequency Data Technology in Patients Diagnosed With Ankylosing Spondylitis

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Objective—The present study aims to identify the cardiovascular risk associated with chronic inflammation and disease activity in patients with ankylosing spondylitis (AS) using noninvasive ultrasonographic radiofrequency data technology.

Methods—In this study, a total of 87 participants, 38 patients with AS and 49 healthy controls, were evaluated by Doppler ultrasonography. Intima-media thickness (IMT) and arterial stiffness were measured from the bilateral common carotid artery using the radiofrequency method.

Results—No statistically significant difference was found between the AS patients and healthy controls concerning the right common carotid artery, left common carotid artery, IMT, distensibility coefficient, elasticity coefficient, α and β stiffness indexes, and pulse wave velocities ($P > .05$). The symptom duration of the AS patients had a positive correlation that was moderate and was detected with the α stiffness index and pulse wave velocity ($P < .05$). The duration of diagnosis and treatment of the AS patients had a positive correlation that was moderate, was detected with the α stiffness index, the β stiffness index, and pulse wave velocity ($P < .05$). The mean IMT and elasticity coefficient values of the AS patients whose Bath Ankylosing Spondylitis Disease Activity Index score was 4 and above, were substantially higher than the values in the patients with scores lower than 4 ($P = .038$ and $P = .33$, respectively).

Conclusions—Subclinical atherosclerosis is not accelerated in AS patients with low disease activity, although insufficiently controlled disease activity may result in increased carotid IMT and atheromatosis. Radiofrequency data technology provides a noninvasive method for accurately and quantitatively demonstrating CCA-IMT elevation and the decrease in vascular elasticity in patients with AS.

Key Words—ankylosing spondylitis; atherosclerosis; intima-media thickness; sonographic radiofrequency data technology

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Abbreviations
AS, ankylosing spondylitis; BASDAI, Bath Ankylosing Spondylitis Disease Activity Index; CCA, common carotid artery; CVD, cardiovascular disease; IMT, intima media thickness; PWV, pulse wave velocity

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Ankylosing spondylitis (AS) is a chronic inflammatory disease that is characterized by bilateral sacroiliitis, inflammatory axial joint arthritis, and several extra-articular manifestations and is associated with human leukocyte antigen B27, which is a prototype of spondyloarthropathies.[1] Patients with AS face an increased risk of cardiovascular disease (CVD)

compared with the general population.[2] As inflammatory arthritis, including AS, represents independent risk factors for CVD, cardiovascular (CV) risk screening and treatment are recommended under all conditions in which inflammation is present.[3] Systemic inflammation is considered as the reason for the high CV risk seen in inflammatory arthropathies and accelerates atherosclerosis by causing the development of endothelial dysfunction, the activation of the coagulation cascade, the induction of secondary dyslipidemia, an increased sensitivity of atheromatous plaques, and widespread coronary artery calcification.[4] The effects of subclinical atherosclerotic changes are manifested on the arterial wall by an increase of intima-media thickness (IMT) and decreasing vascular elasticity.[5]

High-resolution B-mode ultrasonography and carotid IMT measurement are currently the most popular techniques for the evaluation of early structural changes in the arterial wall.[6] Arterial stiffness is an important marker of vascular dysfunction and represents an independent risk factor for CVD.[7] Vascular stiffness, distensibility, and strain, as well as the pressure-strain elastic modulus, are all valid parameters with which to evaluate the reduction in arterial elasticity.[5] Recent improvements in ultrasonographic technologies have allowed automated and accurate measurements of carotid IMT, while the measurement of arterial elasticity is now possible through the use of ultrasonographic radiofrequency (RF) data technology.[5] In the present study, common carotid artery (CCA) IMT and arterial stiffness were measured in AS patients noninvasively using RF data technology and on the controls, who had CVD or who had no known CV risk factor. The findings of the two groups were compared and analyzed with a comparison of the clinical and laboratory data of the patient group. An investigation was conducted for the relationship between inflammation and disease activity with arterial stiffness in AS patients, and the risk of early vascular disease was evaluated.

Methods and Materials

Study Group and Clinical Assessment

The present study was conducted between February 2017 and October 2017 in 38 AS patients (aged 23–60 years), who were followed by the Department of Rheumatology and had no other inflammatory rheumatoid disease, and 49 healthy controls (aged 23–60 years). Symptom duration refers to the time from the date when the first symptoms of the disease were noted until the date the patient was enrolled in this study, and the duration of the diagnosis and treatment refers to the time interval between the date the patient received an AS diagnosis and started treatment until the date of enrollment in this study. All patients met the 1984 modified New York criteria for AS.[8] To assess the disease activity, we used the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI).[9] Patients were allocated to an inactive disease group if their BASDAI score was below 4 and to an active disease group if their BASDAI score was greater than 4.

Patients and control group cases with coronary artery disease, peripheral artery disease, hypertension, hyperlipidemia, diabetes mellitus, chronic renal failure, and patients who were using drugs that affect arterial stiffness (eg, antihypertensive, antidiabetic, and antilipidemic drugs) were excluded from this study. The Clinical Trials Ethics Committee approved this study (Approval No. 16.01.17/34/23), and this study was conducted in accordance with the principles of the Declaration of Helsinki. Each participant provided a written informed consent.

Ultrasonographic Assessment

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured after approximately 10 minutes of resting, using the oscillometric method in the ultrasonography unit of the radiology department (M-6; Omron Healthcare Company, Limited, Kyoto, Japan). Pulse pressure was calculated by subtracting DBP from SBP. Height (m), weight (kg), body mass index (kg/m^2) measurements of the patient and control groups were recorded in ultrasonograpy unit on the same day with carotid IMT measurements.

The patients' identification information and their SBP and DBP values were recorded to the ultrasonography device that functioned on the Esaote MyLab60 platform (Esaote Medical Systems, Italy) with high-resolution 12-MHz linear sequence transducer (LA523). The device was equipped with RF-QIMT and RF-QAS software that worked using RF

method. The measurements were obtained at 45-degree head elevation in the lying position, while the head was rotated to the left or the right at 30 degrees, based on the location of the examined carotid system. Intima media thickness measurements were obtained from B-mode examinations, using RF ultrasound monitoring technology (RF-QIMT) from the CCA distant wall at a 10-mm distal segment, where the appropriate images were obtained from the longitudinal plane, and no plaque was visualized. To run the software, first, the "Tools" button on the device was tapped. The same button was tapped once more on the pop-up screen to activate RF-QIMT. After six cardiac cycles, the software calculated a real-time mean IMT value and its standard deviation (SD). When the SD value was below 20, the color of the SD value shown in the small box located next to the IMT measurement area turned green. The screen was paused at this stage, and the button on the front console was tapped to record the side of the CCA from which the measurement was obtained (Figure 1). The same steps were repeated on the CCA on the other side, and the appropriate CCA side was recorded. Afterwards, "Measurement" was tapped to numerically show IMT values of both CCAs, as presented in Figure 2.

After IMT measurements were completed, the "Tools" button was tapped again, and "RFQAS" software was selected. Using the RFQAS software, arterial wall movements were monitored by RF signals at systole and diastole phases during six cardiac cycles in B mode examinations, and real-time mean arterial distension, diameter and SD values were calculated. Where appropriate SD values lower than 25 were achieved, the color of the small box showing the SD value adjacent to the measurement area turned green. The screen was paused at this stage, and the button on the front console was tapped to record the side of the CCA from which the measurement was obtained.

Parameters obtained with RF-QAS technology are defined as RFQAS. These parameters are calculated using the following formulas.[10,11] The parameters D and DD refer to diastolic diameter and the change of diameter in systole, respectively. Ps and Pd are SBP and DBP, DP is pulse pressure, and r is the blood density.

1. The parameter DC refers to the absolute change in vessel diameter during systole for a given pressure change and is calculated using the following formula:

$$\mathrm{DC} = \frac{2 \cdot D \cdot \Delta D + \Delta D^2}{D^2 \cdot \Delta P}.$$

2. The parameter CC is the relative changes in the vessel diameter during systole for a given pressure change and is calculated using the following formula:

Figure 1. Left common carotid artery (CCA) quality intima-media thickness (QIMT) analysis: The red line represents the radiofrequency (RF) signal following the anterior edge of the media-adventitia interface, and the green line represents the RF signal following the anterior edge of the lumen-intima interface.

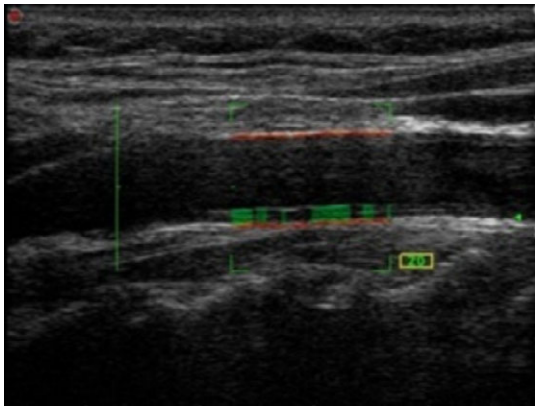
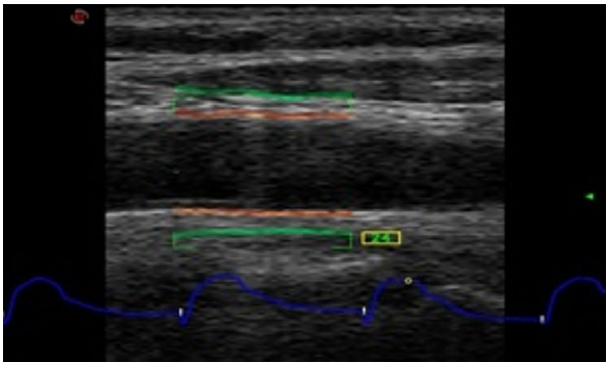


Figure 2. Quality arterial stiffness (QAS) analysis of the right common carotid artery (CCA): The red and green lines represent the radiofrequency signals following the anterior edge of the lumen-intima and media-adventitia interfaces, respectively.



$$CC = \frac{\pi \cdot (2 \cdot D \cdot \Delta D + \Delta D^2)}{4 \cdot \Delta P}.$$

3. The parameter α relates cross-sectional area change to driving pressure, and is calculated as follows:

$$\propto = \frac{D^2 \cdot \ln(P_s/P_d)}{2 \cdot D \cdot \Delta D + \Delta D^2}.$$

4. The parameter β indicates the degree of atherosclerosis, and it increases in the presence of atherosclerosis.

$$\beta = \frac{D \cdot \ln(P_s/P_d)}{\Delta D}.$$

5. The parameter PWVβ is the propagation speed of the pulse wave. PWVβ will be higher if the artery is stiffer.

$$PWV\ \beta = \sqrt{\frac{D^2 \cdot \Delta P}{\rho \cdot (2 \cdot D \cdot \Delta D + \Delta D^2)}}.$$

Figures 3 and 4 show the quality arterial stiffness analysis of the right CCA and atherosclerosis values of both CCAs.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) for Windows version 22.0 (IBM Corp., Armonk, NY). Descriptive statistics were expressed as mean ± standard deviation (min-max), frequency, and percentages. Pearson's chi-square test was used to analyze categorical variables. Visual (histograms and probability diagrams) and analytic methods (Shapiro-Wilk test) were used to check whether the variables were normally distributed. For normally distributed variables, Student's *t* test was used to check any statistically significant differences between 2 independent groups. The Mann-Whitney U test was used to analyze the abnormally distributed variables. The relationship between the variables was analyzed using Spearman's correlation coefficients. A *P* value of less than .05 was considered statistically significant.

Results

Thirty-eight patients diagnosed with AS (age 39.6 ± 11.4 years) and 49 healthy controls (age 35.5 ± 8.4 years), were included in this study. Table 1 shows the demographic and clinical characteristics of AS patients and the control group.

There was no statistically significant difference between the AS patients and the healthy controls regarding right CCA and left CCA, and IMT was calculated as the mean value of the right and the left sides, distensibility coefficient, elasticity coefficient, α and β stiffness indexes, and pulse wave velocities ($P > .05$). Table 2 shows the distribution of the right and the left CCA hemodynamic parameters between the AS patients and the healthy controls. In addition,

Table 1. Demographic and Descriptive Clinical Characteristics of Patients With Ankylosing Spondylitis and Healthy Controls

	AS (n = 38)	Control (n = 49)	
	Mean ± SD (min-max)	Mean ± SD (min-max)	*P* Value
Age, year	39.6 ± 11.4 (23–60)	35.5 ± 8.4 (23–60)	.104[a]
Sex, n (%)			
Male	22 (57.9)	20 (40.8)	.114
Female	16 (42.1)	29 (59.2)	
BMI (kg/m^2)	25.3 ± 3.7 (19.4–29.9)	24.3 ± 3.1 (18.8–29.9)	.277[a]
SBP (mm Hg)	119.3 ± 10.4 (93–130)	118.1 ± 11.0 (93–130)	.597[b]
DBP (mm Hg)	78.0 ± 9.2 (54–89)	76.0 ± 9.6 (50–89)	.351[b]
Pulse (beats/min)	77.3 ± 4.4 (65–80)	76.8 ± 4.7 (60–80)	.610[b]

[a]Mann-Whitney U test.
[b]Student's *t* test.
BMI indicates body mass index; DBP, Diastolic blood pressure; SBP, systolic blood pressure; SD, standard deviation.

no statistically significant difference was found in the laboratory parameters between the AS patients and healthy controls ($P > .05$) (Table 3).

The AS patients' mean symptom duration was 12.8 ± 10.7 (range, 2–40) days and mean diagnosis and treatment duration was 8.0 ± 8.1 (range, 1–40) days, while average BASDAI was 3.8 ± 1.1 (range, 2.4–6.5); 39.5% of the AS patients had a score of 4 or higher (Table 4).

The age and body mass index value of the AS patients had a strong negative correlation with DC and CC measurements ($P < .05$), while a strong positive correlation was detected with the α stiffness index, β stiffness index, and pulse wave velocity (PWV) ($P < .05$). Symptom duration of the AS patients had a moderate positive correlation was detected with the α stiffness index, and PWV ($P < .05$). The duration of diagnosis and treatment of the AS patients had a moderate positive correlation detected with the α stiffness index, β stiffness index, and PWV ($P < .05$) (Table 5).

Mean PWV value of the AS patients had a moderate positive correlation, and a statistically significant relation was detected with cholesterol, triglyceride,

Table 2. Distribution of the Carotid Artery Hemodynamic Parameters Between AS Patients and the Healthy Controls

	AS (n = 38)	Control (n = 49)	
	Mean ± SD (min-max)	Mean ± SD (min-max)	*P* Value[a]
Right IMT (μm)	513.4 ± 116.0 (342–846)	498.3 ± 109.6 (237-757)	.357
Right DC (1/kPa)	0.024 ± 0.018 (0.00–0.08)	0.025 ± 0.010 (0.01-0.05)	.116
Right CC (mm^2/kPa)	0.095 ± 0.537 (0.13–2.24)	0.949 ± 0.386 (0.20–2.16)	.685
Right α Stiffness Index	5.23 ± 4.28 (0.92–20.86)	4.20 ± 2.72 (0–13.71)	.206
Right β Stiffness Index	10.41 ± 8.45 (1.92–41.98)	8.68 ± 5.34 (3.68–27.66)	.162
Right PWV (m/s)	7.48 ± 2.81 (3.50–15.84)	6.58 ± 1.75 (4.34–12.15)	.252
Left IMT (μm)	569.2 ± 180.8 (248–1270)	519.5 ± 121.0 (49.9–833)	.756
Left DC (1/kPa)	0.027 ± 0.018 (0–0.08)	0.027 ± 0.013 (0–0.06)	.316
Left CC (mm^2/kPa)	1.042 ± 0.574 (0.08–2.24)	0.990 ± 0.416 (0.05–2.12)	.627
Left α Stiffness Index	5.24 ± 5.86 (0.88–34.89)	5.08 ± 9.07 (1.44–65.65)	.183
Left β Stiffness Index	10.34 ± 11.83 (1.88–70.11)	10.36 ± 18.17 (3.02–131.64)	.180
Left PWV (m/s)	7.32 ± 3.73 (3.48–24.19)	6.72 ± 3.13 (3.90–24.91)	.180
Mean IMT (μm)	551.3 ± 133.9 (337–1058)	508.9 ± 90.6 (242.4–658.0)	.239
Mean DC (1/kPa)	0.025 ± 0.016 (0.01–0.08)	0.026 ± 0.010 (0.01–0.06)	.182
Mean CC (mm^2/kPa)	1.000 ± 0.479 (0.30–2.21)	0.970 ± 0.349 (0.26–1.97)	.905
Mean α Stiffness Index	5.24 ± 3.65 (0.90–18.93)	4.64 ± 5.03 (0.96–36.13)	.238
Mean-β Stiffness Index	10.38 ± 7.21 (1.90–38.10)	9.52 ± 10.06 (3.35–72.60)	.308
Mean PWV (m/s)	7.04 ± 2.52 (3.49–15.27)	6.65 ± 2.03 (4.12–16.42)	.176

[a]Mann-Whitney U test.
CC indicates elasticity coefficient; DC, distensibility coefficient; IMT, intima-media thickness; PWV, pulse wave velocity; SD, standard deviation.

Table 3. Distribution of Laboratory Parameters in Patients With AS and Healthy Controls

	AS (n = 38)	Control (n = 49)	
	Mean ± SD (min-max)	Mean ± SD (min-max)	*P* Value[a]
Glucose (mg/dL)	84.0 ± 9.3 (69–99)	84.6 ± 8.4 (64–100)	.535
CRP (mg/dL)	13.5 ± 10.8 (2.1–49.0)	4.8 ± 2.3 (1.0–7.9)	.146
ESR (mm/h)	20.4 ± 12.6 (2–69)	15.6 ± 11.7 (2–17)	.059
Cholesterol (mg/dL)	175.0 ± 27.5 (105–200)	170.4 ± 23.7 (118–200)	.173
Triglyceride (mg/dL)	99.4 ± 31.2 (37–170)	89.0 ± 35.1 (39–185)	.077
LDL (mg/dL)	120.4 ± 26.3 (60–156)	112.7 ± 23.2 (65–159)	.088
HDL (mg/dL)	48.3 ± 12.0 (15–77)	50.0 ± 12.0 (28–78)	.574

[a]Mann-Whitney U test.
CRP indicates C-reactive protein; ESR, erythrocyte sedimentation rate; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SD, standard deviation.

and high-density lipoprotein values ($P < .05$) (Table 6). The mean IMT and elasticity coefficient values in the AS patients with BASDAI scores of 4 and above were substantially higher than the values of patients with BASDAI scores below 4 ($P = .038$; $P = .33$, respectively) (Table 7).

Discussion

To our knowledge, this is the first study in the literature to noninvasively investigate the contribution of early inflammation and disease activity to the future risk of CVD in AS patients through the use of RF data technology. In the present study, no substantial differences were identified between the CCA IMT and stiffness measurements of the AS patients and those of the control group. However, the IMT of patients with active AS was higher than that of patients with inactive AS.

Cross-sectional studies that compared patients with ankylosing spondylitis with healthy controls have shown an elevated arterial stiffness, particularly for PWV, in this patient group.[12] Mechanically, inflammation leads to arterial stiffness by stimulating changes in the arterial wall, endothelium, muscular tonus, and structural components.[13]

In a study by Serdaroğlu and colleagues,[14] carotid IMT and PWV values were found to be higher than the controls, and PWV values were substantially different between patients with AS with low and high disease activity.[14] Mathieu and colleagues[7] also reported higher carotid IMT and greater arterial stiffness in patients with AS than the controls, although the difference was not statistically significant. In another study, including age- and gender-matched AS patients and controls, normal IMT values were reported in AS patients,[1] and in a further study, PWV values were not found to be substantially different between patients with AS and healthy controls.[15] Similarly, CCA IMT and stiffness values in the present study were not found to be substantially different between patients with AS and the controls.

Table 4. Symptom, Diagnosis and Treatment Durations, Bath Ankylosing Spondylitis Disease Activity Index, and Drugs Used by Patients Diagnosed With AS

AS Patients	(n = 38)
Symptom duration (year), mean ± SD (min-max)	12.8 ± 10.7 (2–40)
Diagnosis and treatment duration (year), mean ± SD (min-max)	8.0 ± 8.1 (1–40)
BASDAI, mean ± SD (min-max)	3.8 ± 1.1 (2.4–6.5)
<4, n (%)	23 (60.5)
≥4, n (%)	15 (39.5)
Medication, n (%)	
NSAIDs	11 (28.9)
DMARD + NSAIDs	27 (71.1)
Anti-TNF	4 (10.5)

BASDAI indicates Bath Ankylosing Spondylitis Disease Activity Index; DMARD, disease-modifying antirheumatic drug; NSAIDs, nonsteroidal anti-inflammatory drugs; SD, standard deviation; TNF, tumor necrosis factor.

Table 5. The Relationship Between the Age of Patients With AS, Body Mass Index Value, Bath Ankylosing Spondylitis Disease Activity Index, Symptom Duration, Duration of Diagnosis and Treatment, and Mean Carotid Artery Hemodynamic Results

(n = 38)		Age, y	BMI (kg/m^2)	BASDAI	Symptom Duration	Diagnosis-Treatment Duration
Mean IMT (μm)	r	0.229	−0.008	0.201	0.276	0.227
	p	0.167	0.963	0.225	0.094	0.170
Mean DC (1/kPa)	r	−0.631	−0.597	0.154	−0.296	−0.255
	p	<0.001	<0.001	0.355	0.071	0.122
Mean CC (mm^2/kPa)	r	−0.528	−0.534	0.307	-0.219	−0.219
	p	0.001	0.001	0.061	0.186	0.186
Mean α Stiffness Index	r	0.670	0.504	−0.188	0.325	0.373
	p	<0.001	0.001	0.259	0.046	0.021
Mean -β Stiffness Index	r	0.643	0.503	−0.168	0.304	0.352
	p	<0.001	0.001	0.313	0.063	0.030
Mean -PWV (m/s)	r	0.713	0.560	−0.163	0.375	0.389
	p	<0.001	<0.001	0.329	0.020	0.016

BASDAI indicates Bath Ankylosing Spondylitis Disease Activity Index; BMI, body mass index; DC, distensibility coefficient; IMT, intima-media thickness; CC, elasticity coefficient; PWV, pulse wave velocity; r, Spearman correlation coefficient.

In a meta-analysis carried out by Arida and colleagues[16] on patients with AS and healthy subjects, carotid IMT measurements of a subgroup of patients with AS with BASDAI scores lower than 4 were found to be equal to the measurements recorded in the controls. The authors suggested that subclinical atherosclerosis was not accelerated in patients with AS with low disease activity but reported that active AS was associated with an increase in carotid IMT values.[16] In the present study, the mean IMT of patients with AS whose BASDAI scores were 4 and above was substantially higher than the mean IMT of patients whose BASDAI scores were lower than 4.

Table 6. The Relationship Between Certain Laboratory Parameters of Patients With AS and Their Carotid Artery Intima Media Thickness and Pulse Wave Velocity Values

(n = 38)		Mean IMT (μm)	Mean PWV (m/s)
Glucose (mg/dL)	r	−0.113	0.010
	p	0.500	0.954
CRP (mg/dL)	r	0.113	−0.070
	p	0.501	0.675
ESR (mm/h)	r	−0.154	−0.148
	p	0.355	0.374
Cholesterol (mg/dL)	r	0.010	0.442
	p	0.954	0.005
Triglyceride (mg/dL)	r	0.092	0.488
	p	0.584	0.002
LDL (mg/dL)	r	0.064	0.440
	p	0.702	0.006
HDL (mg/dL)	r	−0.263	0.061
	p	0.110	0.716

CRP indicates C-reactive protein; ESR, erythrocyte sedimentation rate; HDL, high-density lipoprotein; LDL, low-density lipoprotein; r, Spearman Correlation Coefficient;

Chronic inflammation contributes to all phases of atherosclerosis, which can account for the negative effects of AS on arterial remodeling.[17] The presence of IMT increase does not by itself suggest that there is also an increase in atheromatosis, but it may be associated with subclinical vasculitis and/or wall hypertrophy.[16] The absence of an increase in carotid IMT in patients with AS with low disease activity may be attributed to the resolution of vascular wall inflammation.[18] In their study, Berg and colleagues[12] found out that PWV values were elevated in patients with high C-reactive protein and Ankylosing Spondylitis Disease Activity Score,[12] and they concluded that disease activity is associated with increased arterial stiffness and future risk of CVD and that AS patients with high disease activity are under high risk of developing CVD.[12,15] Active AS results in impairment of vascular elasticity and function,[16] while preclinical atherosclerosis in patients with AS is associated with CV risk factors, disease duration, and CRP levels.[14] Decreasing inflammation and disease activity in patients with AS is crucial in reducing the risk of CVD,[13,15] and the present study supports this opinion, based on the significant relationships identified between mean PWV values and cholesterol, triglyceride, and high-density lipoprotein levels, and also between symptom duration, diagnosis and treatment duration, and parameters of arterial stiffness in patients with AS.

Chronic inflammation, particularly in people with rheumatologic disorders, results in an acceleration of atherogenesis.[19] Carotid IMT is a valid tool for the measurement of early preclinical atherosclerosis and serves as a precursor of future CVD.[20] Today, researchers tend to focus on noninvasive methods

Table 7. Distribution of Hemodynamic Parameters Among Patients With AS With BASDAI Below 4 and BASDAI Above 4

	BASDAİ < 4 (n = 23)	BASDAİ ≥ 4 (n = 15)	
AS Patients	Mean ± SD (min-max)	Mean ± SD (min-max)	P Value[a]
Mean IMT (μm)	516.7 ± 108.2 (337–866.5)	604.4 ± 155.0 (417–1058)	0.038
Mean DC (1/kPa)	0.025 ± 0.019 (0.01–0.08)	0.027 ± 0.011 (0.01–0.05)	0.172
Mean CC (mm^2/kPa)	0.897 ± 0.530 (0.30–2.21)	1.148 ± 0.353 (0.64–1.69)	0.033
Mean α Stiffness Index	5.47 ± 3.20 (0.90–12.08)	4.88 ± 4.35 (1.94–18.93)	0.191
Mean β Stiffness Index	10.86 ± 6.31 (1.90–24.38)	9.64 ± 8.59 (4.03–38.10)	0.191
Mean PWV (m/s)	7.65 ± 2.36 (3.49–11.42)	7.01 ± 2.79 (4.65–15.27)	0.213

[a]Mann-Whitney U test.
CC indicates elasticity coefficient; DC, distensibility coefficient; IMT, intima-media thickness; PWV, pulse wave velocity; SD: standard deviation.

when they measure endothelial dysfunction and atherosclerosis, in other words, the measurement of arterial stiffness.[21] Arterial stiffness is a valid risk marker for CV events and is affected by chronic inflammation.[12] PWV is considered the gold standard measurement method for the identification of arterial stiffness.[22] Studies have demonstrated that the effective management of rheumatologic disease progressing with chronic inflammation, such as AS, can reverse arterial stiffness with simultaneous improvement in clinical and laboratory markers of inflammation, and can also improve markers of arterial function.[16]

Conclusion

Subclinical atherosclerosis is not accelerated in patients with AS with low disease activity, although insufficiently controlled disease activity may result in increased carotid IMT and atheromatosis. The effective management of disease activity in patients with AS minimizes the CV burden.

Study Limitations

The present study has some limitations. This single-center study was carried out on a small patient population that comprised mostly young patients with short disease duration. The parameters investigated in this study may become more notable in a larger cohort with a wider age range and longer disease duration. In addition, the inter- and intraobserver reliability of was not measured. Further studies are therefore required to provide valuable insights.

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