Scanning of the Sacroiliac Joint and Entheses by Color Doppler Ultrasonography in Patients with Ankylosing Spondylitis

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ABSTRACT. ***Objective.*** To assess Doppler ultrasonography by comparing its detection of sacroiliitis with detection of enthesitis in patients with ankylosing spondylitis (AS).

Methods. One hundred sixty-one patients with AS (according to modified New York criteria or Spondyloarthritis International Society classification criteria for axial spondyloarthritis) underwent ultrasonography (US) of the sacroiliac joint (SIJ) and major entheses of the lower limbs. Vascularization of the SIJ and morphologic changes and vascularization of entheses were observed. The resistive index of the SIJ was measured. Doppler ultrasonography examination was repeated in 20 patients by another ultrasonographer.

Results. In the AS active group [Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) ≥ 4], 90.7% of SIJ showed vascularization; this was significantly more than in the inactive group (38.5%). The resistive index of the active group in the SIJ area was significantly lower than that of the inactive group. Doppler US scanning of the SIJ was more sensitive (92.0%) than that of the entheses (52.2%). Agreement of Doppler US scanning of the SIJ and BASDAI was good, while agreement of the entheses and BASDAI was poor.

Conclusion. Lower resistive index value and vascularization in the SIJ had good agreement with AS activity. Doppler US is more sensitive in detecting sacroiliitis than in detecting enthesitis. (First Release May 15 2011; J Rheumatol 2011;38:1651–5; doi:10.3899/jrheum.101366)

Key Indexing Terms:
DOPPLER ULTRASONOGRAPHY
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Ankylosing spondylitis (AS) is the prototype of the spondyloarthropathies as a chronic inflammatory rheumatic disease presenting mainly with inflammation of the axial skeleton, peripheral arthritis, and enthesitis[1]. Its prevalence ranges up to 0.9% worldwide, and men are affected more often than women[2]. Sacroiliitis is one of the earliest manifestations of AS[3], and enthesitis also may manifest early. Diagnosing AS before the occurrence of irreversible damage can be difficult. Radiography [mainly plain radiographs and computed tomography (CT)] is the classic imaging technique for AS and a basic part of the modified New York criteria for diagnosing and classifying AS[4]. The Spondyloarthritis International Society has developed new classification criteria for axial spondyloarthropathies (including patients with radiographic and nonradiographic sacroiliitis)[5]. Magnetic resonance imaging (MRI) shows the structural changes of the sacroiliac joints (SIJ) and is used like plain radiography or CT.

Ultrasonography (US) is an imaging technique increasingly used by clinicians, especially for spondyloarthropathies. Lehtinen, *et al*[6] and Balint, *et al*[7] first used B-mode US and high-frequency US to observe enthesitis in the spondyloarthropathies. Color Doppler ultrasonography (CDUS) represents the abnormal vascularization of entheses directly at the site of inflammation[8,9]. Moreover, several studies have shown that signs of active sacroiliitis can be detected by CDUS[10,11,12]. Klauser and associates[13] have indicated that the sensitivity and specificity of CDUS were close to those of MRI. Our preliminary study that used CDUS to observe the SIJ of patients with AS and healthy volunteers concluded that CDUS also can show vascularization in active sacroiliitis[14]. In our current study, we aimed to observe vascularization of the SIJ using CDUS and to assess CDUS detection of sacroiliitis by comparing it with CDUS detection of enthesitis.

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MATERIALS AND METHODS

Patients. One hundred sixty-one patients were recruited from our nephrology and rheumatology departments from 2008 to 2009. They had a diagnosis of AS according to the modified New York criteria or the Spondyloarthritis International Society classification criteria for axial spondyloarthritis (which excludes past or present rheumatoid arthritis and other causes of arthritis). HLA-B27, C-reactive protein, and erythrocyte sedimentation rate results were examined. The "gold standard" for measuring and evaluating disease activity in AS is the Bath AS Disease Activity Index (BASDAI). In our study, BASDAI was scored to determine active AS. Patients were considered as having active AS if BASDAI ≥ 4. The active group was composed of 103 males and 10 females (age 11–48 yrs; mean 26 ± 9 yrs). There were 34 males and 14 females in the inactive group (age range 12–44 yrs; mean 30 ± 11 yrs). This study was approved by the Ethical Committee of Shanghai Jiaotong University Affiliated Sixth People's Hospital.

Ultrasonography. US was performed with an Acuson Sequoia 512 unit (Siemens Medical Systems Inc., Mountain View, CA, USA). A 4-MHz to 6-MHz convex array transducer was used when observing the SIJ. Standard US measurements were used including color Doppler gain 50–60 db and wall filter 30–40 Hz. When observing entheses, we used a high frequency 14-MHz linear array transducer; color Doppler gain was 60–80 db and wall filter 30–40 Hz. All patients were examined by the same experienced ultrasonographer and the examination was repeated in 20 patients by another trained ultrasonographer. Both were blinded to clinical data and other imaging findings. The interobserver agreement was good (κ = 0.851).

Sacroiliac joint. All patients were examined in the prone position. The probe was transversely placed at the sacral bone. The sound beam was inclined downward, and then the SIJ could be scanned. The probe was then turned counterclockwise somewhat at the left SIJ and clockwise at the right SIJ to reveal the joints more clearly. Color Doppler signals in or around the SIJ were observed using CDUS. When the color Doppler signal was found in or around the SIJ, spectral Doppler was used and the resistive index (RI) was measured; this was repeated 3 times at the superior, middle, and inferior part of the SIJ. If it shows an arterial spectrum on the spectral Doppler, the mean value of the RI was recorded.

Entheses. For each patient, the following entheses were examined bilaterally: the patellar ligament insertion at the tibia, medial collateral ligament, lateral collateral ligament, the Achilles tendon, and the plantar fascia insertion at the calcaneus. Each tendon was examined in its longitudinal and transverse planes. First, we used B-mode US to detect morphologically abnormal entheses, such as the thickness and echoes of the tendons, calcification of the tendon insertions, and proliferation or erosion of the periosteum near the tendon insertions. Then CDUS was used to detect abnormal vascularization of the tendons and entheses. When detecting blood flow, the probe should not vibrate.

US of entheses were divided into 3 groups: type A = no abnormal findings in both B-mode and CDUS; type B = swelling and/or decreased echogenicity, and/or calcification of tendon insertions and/or proliferation of periosteum, and no color Doppler signals found in entheses; and type C = color Doppler signals found in entheses with or without abnormal findings in B-mode[15].

Statistical analysis. Differences between groups were assessed by the chi-squared test (categorical data) or the t-test (numerical data). Values for $p < 0.05$ were considered statistically significant. Unweighted κ values were calculated between ultrasonographers, BASDAI scores, and the 2 examinations (CDUS scanning of SIJ and entheses).

RESULTS

A total of 322 SIJ and 1610 entheses were examined. Demographics and clinical characteristics are summarized in Table 1.

Ultrasound scanning of the sacroiliac joints. The results of scanning of the SIJ by US in the active and inactive AS groups are shown in Table 2. In the AS active group, 90.7% of the SIJ were shown to have vascularization; this was significantly more than in the inactive group ($p < 0.01$).

Table 1. Demographic and clinical characteristics of patients with ankylosing spondylitis (AS). Values are the number unless otherwise indicated.

Characteristics	Active AS, n = 113	Inactive AS, n = 48
Male/female	103/10	34/14
Age, yrs, mean ± SD	26 ± 9	30 ± 11
Duration, yrs, mean ± SD	4 ± 3	6 ± 4
CRP, mg/l, mean ± SD	36.20 ± 30.35	5.62 ± 4.69
ESR, mm/h, mean ± SD	43 ± 29	18 ± 15
HLA-B27, positive/negative	91/22	31/17
BASDAI score, mean ± SD	5.7 ± 1.6	3.0 ± 1.4

CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; BASDAI: Bath Ankylosing Spondylitis Disease Activity Index.

Table 2. Color Doppler signals and resistive index values of the sacroiliac joint (SIJ) in patients with ankylosing spondylitis (AS). Values are expressed as number (%) unless otherwise indicated.

	Active AS (226 SIJ)	Inactive AS (96 SIJ)
Color Doppler signals found in/around SIJ	205 (90.7)	37 (38.5)
Resistive index, mean ± SD	0.56 ± 0.08 (201 SIJ)	0.79 ± 0.07 (29 SIJ)

Using spectral Doppler scans, we found arterial and/or venous flows in the vascularized SIJ. When the spectrum showed an arterial flow rather than a venous flow, or an arterial flow representing reversed phase in diastolic phase (Figure 1), we measured the RI value. The mean RI value of the active group in 201 SIJ that showed arterial flow was 0.56 ± 0.08 (range 0.32–0.74); while in 29 SIJ in the inactive group, this value was 0.79 ± 0.07 (range 0.67–0.95). The mean RI for the active group was significantly lower than it was for the inactive group ($p < 0.01$).

There were also 2 venous flows and 2 arterial flows (representing reversed phase in the diastolic phase of the active group), and 6 venous flows and 2 arterial flows (representing reversed phase in the diastolic phase of the inactive group).

Ultrasound scanning of entheses. Observations of entheses by US in the active and inactive AS groups are shown in Table 3 and Figure 2. Type A was considered normal; the others were considered abnormal (enthesitis). Type C was enthesis with vascularization. Enthesitis was found slightly more often in the active group than in the inactive group ($p = 0.04$), but vascularization of an enthesis occurred significantly more often in the active group than in the inactive group ($p < 0.01$).

Sensitivities and specificities of ultrasound scanning of the sacroiliac joints and entheses with BASDAI as a reference method. The sensitivities and specificities of US scanning of the SIJ and entheses with BASDAI as a standard reference method are shown in Table 4. The sensitivity of US was high-

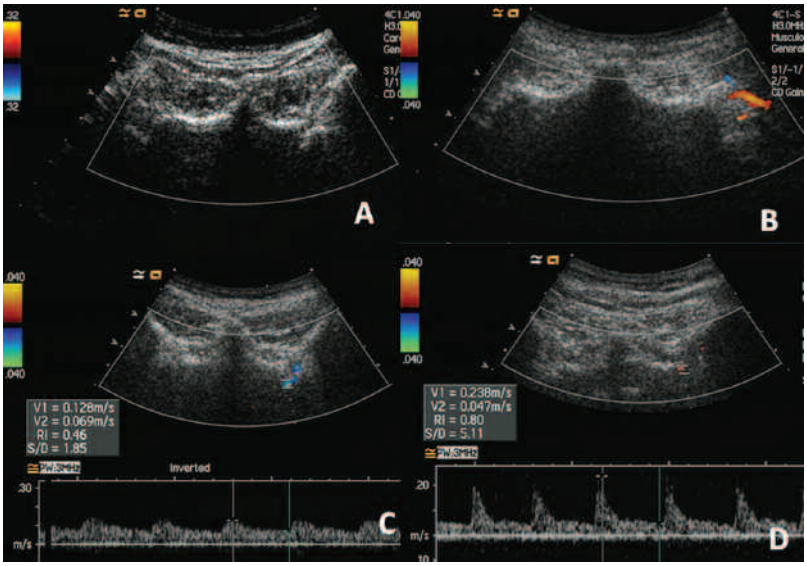

Figure 1. Color Doppler ultrasonography and spectral Doppler images of sacroiliac joints (SIJ) of patients with ankylosing spondylitis. A. No color Doppler signals in either SIJ. B. Color Doppler signals around the left SIJ. C. Color Doppler signals inside the left SIJ showing low resistance (0.47) on spectral Doppler analysis. D. Color Doppler signals inside the left SIJ showing high resistance (0.80) on spectral Doppler analysis.

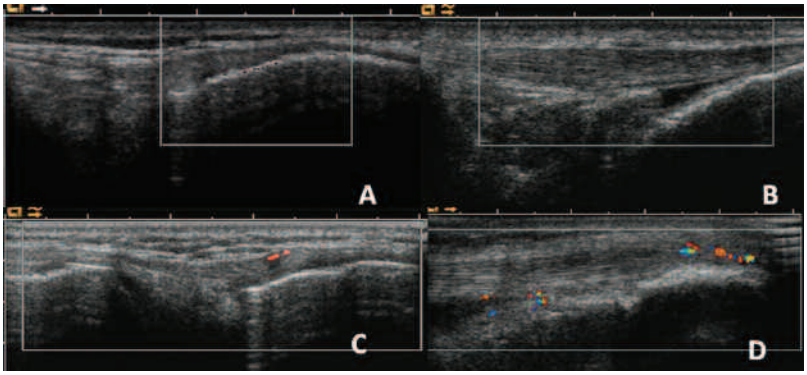

Figure 2. Distinctive patterns of enthesitis detected by color Doppler ultrasonography (CDUS) in patients with ankylosing spondylitis. A. Type A lateral collateral ligament enthesis; no abnormal findings in both B-mode and CDUS. B. Type B lateral collateral ligament enthesis; swelling and decreased echogenicity, no color Doppler signals found. C. Type C lateral collateral ligament enthesis; color Doppler signals were found without abnormal findings in the B-mode. D. Type C patellar ligament enthesis; swelling, decreased echogenicity, and color Doppler signals were found.

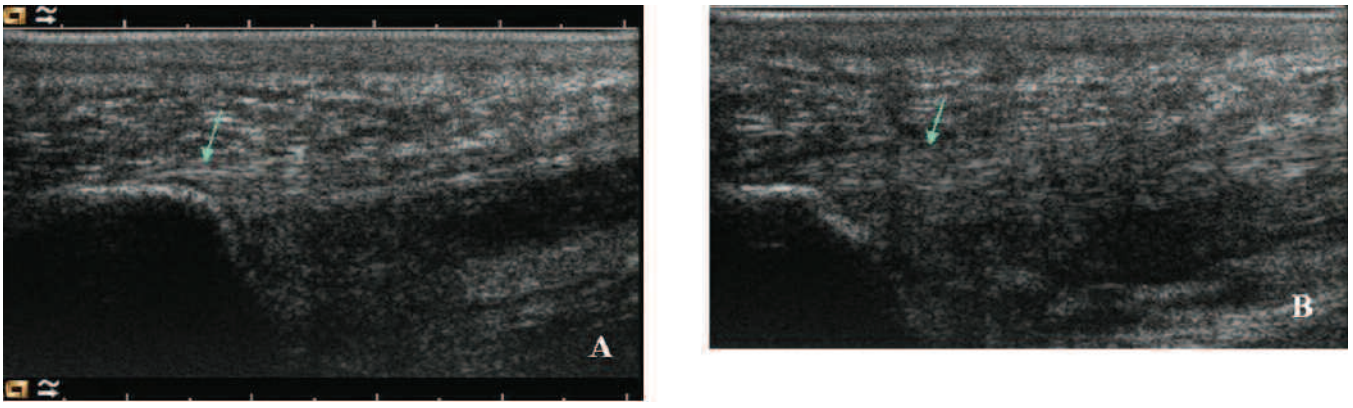

Figure 3. Right plantar fascia (arrow) of a 31-year-old patient with ankylosing spondylitis taking anti-TNF-α therapy. A. Before the treatment. B. Two weeks after treatment.

er when observing SIJ than when observing entheses. The specificities were high for both. US sacroiliitis activity was similar to BASDAI ($p = 0.22$) and agreement between them was good ($\kappa = 0.62$), while US enthesitis activity was different from BASDAI ($p < 0.01$) and the agreement between them was poor ($\kappa = 0.202$).

DISCUSSION

Our main objective was to assess CDUS of the SIJ by comparing it with CDUS of entheses, using the BASDAI in AS. To our knowledge, ours is the first study to compare CDUS of the SIJ with CDUS of entheses in patients with AS. In our study, CDUS of sacroiliitis was more sensitive than CDUS of

enthesitis, and CDUS was similar to BASDAI in assessing disease activity in patients with AS.

Several studies have shown that CDUS can assess sacroiliitis involvement in spondyloarthropathies. Using duplex ultrasound and CDUS, Arslan and associates[11] examined 41 SIJ with active sacroiliitis and 30 SIJ of asymptomatic volunteers. They found that active sacroiliitis showed increased vascularization in the posterior part of the joints and RI was decreased in patients with active sacroiliitis. Unlu and associates[12] also used CDUS to observe the SIJ of patients with active AS and healthy controls, and they found that there was increased color Doppler signal in those patients with active sacroiliitis. The RI was insignificantly lower than that of the inactive group but was significantly increased after anti-tumor necrosis factor-α (TNF-α) therapy.

In our study, the result was similar to Arslan's and to our previous study[16]. There were more SIJ showing vascularization in the active group (90.7%) than in the inactive group (38.5%), and the mean RI value of the active group (0.56 ± 0.08) was significantly lower than that of the inactive group (0.79 ± 0.07). In our previous study[14], the RI of patients with active AS (0.53 ± 0.08) was lower than that of healthy volunteers (0.97 ± 0.01). The lower RI may suggest active sacroiliitis.

Enthesitis is another manifestation of AS, and it usually involves entheses and tendons of the lower limbs. Many researchers have observed enthesitis by US, and by CDUS it shows a different relevance ratio of enthesitis in patients with spondyloarthropathies, ranging from 15% to 56%[7,15,17]. In our study, there were 262 entheses (16.3%) showing abnormal morphologic changes or vascularization, out of 1610 entheses. In the active group, there were 218 abnormal entheses (19.3%). One hundred three entheses showed an abnormal color Doppler signal; 101 of them were in the active group (98.1%). This indicates that vascularization in entheses is closely related to disease activity; however, the prevalence of vascularization in enthesis (6.4%) was too low to assess disease activity in the early stage.

The prevalence of vascularization in the SIJ (75.2%) was higher than it was in entheses. Using BASDAI as a standard reference to assess AS activity, CDUS proved more sensitive when imaging the SIJ than when imaging entheses. The negative predictive value and positive predictive value of the SIJ were both higher than those for the entheses. CDUS examination of the SIJ is more valuable for assessing AS activity, especially in the early stage. We followed a 31-year-old patient with AS who was taking anti-TNF-α therapy. We observed the detumescence of the right plantar fascia 2 weeks after the patient began the treatment (Figure 3). Thus, CDUS may help with treatment decisions and the therapeutic evaluation of patients with AS.

Many studies indicate that MRI has high sensitivity and specificity for the SIJ in spondyloarthropathies[18,19], but it also has some disadvantages, such as it is expensive and takes a long time. Doppler US is lower in cost and is a highly efficient accessory method. Some researchers have suggested that it may be superior to MRI in detecting the early signs of peripheral enthesitis[20,21]. CDUS is more sensitive in examining the SIJ than it is in examining the enthesis. In a future study, we will compare CDUS with MRI.

One of the limitations of our study was that we did not quantitatively evaluate or grade the CDUS findings in the SIJ and entheses. Some studies have tried to quantify or score the vascularization in the SIJ or entheses[9,22], but a standard has not been developed to date.

Abnormal vascularization in the sacroiliac joint and entheses can be detected by CDUS in patients with AS. Lower RI values in the sacroiliac joint and vascularization in the sacroiliac joint and entheses suggest disease activity. Doppler US imaging of the sacroiliac joint is more sensitive than its imaging of entheses, and Doppler US had good agreement with AS activity.

Table 3. Ultrasonography observations of entheses in patients with ankylosing spondylitis (AS). Values are expressed as number (%). Type A.: no abnormal findings in both B mode and color Doppler (CD) ultrasonography; B: swelling and/or decreased echogenicity, and/or calcification of tendon insertions and/or proliferation of periosteum. No CD signals were found in entheses; C: CD signals found in entheses with or without abnormal findings in B mode.

Type	Active AS	Inactive AS
A	912 (80.7)	436 (90.8)
B	117 (10.3)	42 (8.8)
C	101 (8.9)	2 (0.4)

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Table 4. Sensitivity and specificity of observing sacroiliitis and enthesitis by color Doppler ultrasonography, with the Bath Ankylosing Spondylitis Disease Activity Index as a reference method. All values are percentages.

	Sensitivity	Specificity	Negative Predictive Value	Positive Predictive Value	Accuracy
Sacroiliac joint	92.0	68.8	87.4	78.6	85.1
Entheses	52.2	72.9	81.9	39.3	58.4

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