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Lumbar Stiffness but not Thoracic Radiographic Changes Relate to Alteration of Lung Function Tests in Ankylosing Spondylitis

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Abstract: Involvement of the costovertebral (CV) and costotransverse (CT) as well as the sacroiliac (SI) joints is known to occur in patients with ankylosing spondylitis (AS). The functional significance of these changes is not clear. We have performed clinical and radiological evaluations and assessed the effect of joint involvement on pulmonary function. We detected radiologic evidence of involvement of the CV joint in 80% of patients and of the CT joint in 60 %. We found a direct relation between the severity of CV, CT and SI joint affliction, and the severity of CV and SI joints were related to time of evolution of the disease. Pulmonary function tests revealed neither restrictive nor obstructive defects. No relation was found between pulmonary function and CV and CT joint affliction. Patients with stiffer spines had a tendency to have pulmonary function tests within the lower limit of the normal range. In patients with AS diaphragmatic breathing might compensate the chest respiration to some extent.

Keywords: Ankylosing spondylitis; Costovertebral articulation; Pulmonary function tests

Introduction

Ankylosing spondylitis (AS) particularly involves the sacroiliac (SI), apophyseal, discovertebral and costovertebral (CV) articulations in the axial skeleton [1]. Although changes such as erosion, sclerosis and ankylosis are known to occur at CV joints, these changes are difficult to show by conventional radiography [1,2].

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The involvement of thoracic vertebrae, CV, costotransverse (CT), sternoclavicular and sternomanubrial joints results in an increase in dorsal kyphosis and rigidity of the thorax [3]. The changes in CV joints are similar to those reported in the SI joints of AS patients [2,4]. The bony bridges seen in the CV joints look similar to the vertebral syndesmophytes. A common feature of these joints is their mobility, not found in the SI joint.

In patients with AS thoracic pain and respiratory function abnormalities of restrictive type are likely to appear [5,6]. To our knowledge, there is no published study in the English-language literature that quantifies pulmonary function in AS related to the aspect of joint involvement.

The purpose of our study was to determine the involvement of CV, CT and SI joints in our patients with AS by clinical and radiological evaluation and to assess the effect of joint involvement on pulmonary function.

Patients and Methods

Twenty-five patients with AS diagnosed according to the modified NewYork criteria [4] were included in the study. Twenty were male (80%) and five were female (20%). Ages ranged from 20 to 57 years (mean (SD): 38.4 (8.0)). The duration of disease ranged from 0.3 to 38 years (median 9 years). The functional capacities of the patients were assessed with functional and articular indices described by Dougados et al. [7].

The latent time before resolution of early morning stiffness (in minutes) was questioned. The severity of the patients' pain was determined using a visual analogue scale (VAS), on which 0 represented the absence of pain and 10 the existence of maximum pain. The limitation in lumbar flexion was measured with a tape-measure by a

modified Schober's test. After marking 10 cm above and 5 cm below the dimples of Venus, it was considered a limitation if the distance was less than 5 cm between these points in maximal lumbar flexion. In addition, the distance between the patient's hand and the ground when the patient was standing, flexing the trunk forward without bending the knees, was measured (in cm). Chest expansion was measured with a tape-measure placed circumferentially around the chest wall at the fourth intercostal space (in cm).

CT evaluation of the SI, CV and CT joints was performed with a PICKER PQS helical scanner at the Department of Radiology. Scan parameters were applied as kV 130, mA 125, mAs 157.5, exposure time 1.57, thickness 3 mm, index 3 mm. The scans were evaluated blindly by a radiologist who was unaware of the clinical findings. One or two axial cuts were taken at each thoracic joint according to the scanogram of the patients. The severity of involvement of the SI joints was graded according to the New York criteria [6]. The CV and CT joints were similarly graded 04 (normal (0); doubtful (1): minimal sclerosis and changing of articular surfaces; mild (2): minimal erosions; moderate (3): prominent erosion and sclerosis; and severe (4): complete ankylosing in joints). Because we considered that the worst score for each SI joint pair was indicative of the actual degree of severity of joint involvement, only one score per patient was given. For CV and CT joints the joint with the worst involvement was used to evaluate the scoring of the CV and CT joints.

The patients were asked whether they had thoracic pain and, if so, where it was localised. They were also asked whether they had pain during deep breathing or coughing.

Patients' chest X-rays and pulmonary function tests were evaluated by a specialist in chest diseases. Patients with cavitation or findings of infection on chest radiographs were excluded. Pulmonary function tests were performed in the sitting position with MIR Srl model spirometry at the Department of Chest Diseases. Of the pulmonary function parameters, vital capacity (VC), VC(%), forced vital capacity (FVC), FVC(%), forced expiratory volume in one second (FEV_1), FEV_1(%), FEV_1/FVC, peak expiratory flow rate (PEF) and PEF(%) were evaluated. European Respiratory Society 1993 Update values were used as a reference in our spirometry equipment. When VC predicted value was higher than FVC predicted value it was considered normal.

Spearman's correlation analysis in SPSS was performed for the statistical analysis of the data using the MannWhitney U test. P values <0.05 were considered statistically significant. Ethical committee permission had already been sought for this study.

Results

Table 1 shows the distribution of the patients' involvement of SI, CV and CT joints (Figs 1, 2).

Table 1. Distribution of the involvement of sacroiliac, costovertebral and costotransverse joints

Grade	0 *n* (%)	1 *n* (%)	2 *n* (%)	3 *n* (%)	4 *n* (%)
Sacroiliac joint	–	–	11 (44)	5 (20)	9 (36)
Costovertebral joint	5 (20)	2 (8)	5 (20)	5 (20)	8 (32)
Costotransverse joint	10 (40)	3 (12)	6 (24)	1 (4)	5 (20)

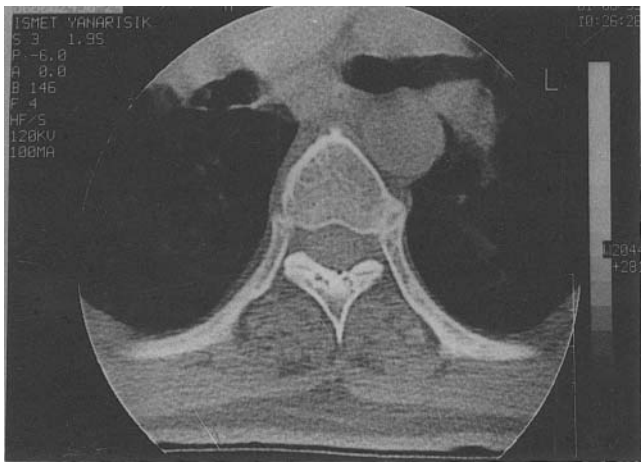

Fig. 1. CT scan of a patient with sclerosis and minimal erosion in CV joint (grade 2).

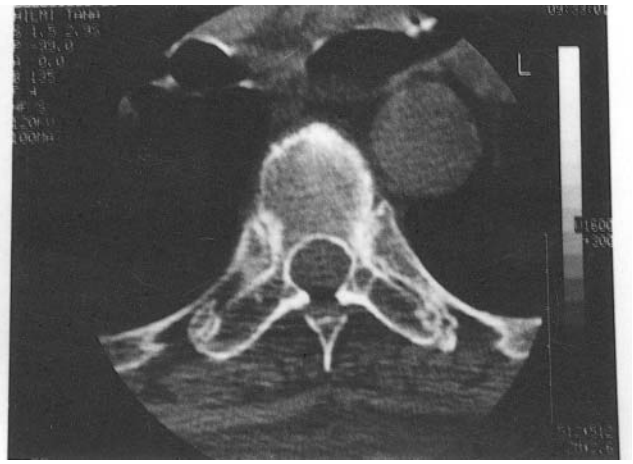

Fig. 2. Complete fusion in CV and CT joints (grade 4).

There was a direct relationship between the severity of involvement of CV, CT and SI joints. There was also a close correlation between physical variables such as chest expansion, modified Schober's test and the handground distance. Chest expansion showed a significant association with computed tomography changes in CV, CT and SI joints. Patients with more advanced computed tomography changes in CV and CT joints had more restricted lumbar motion, as shown by the modified Schober's test. As a result, radiological findings of SI, CV and CT joints and the relationship between clinical findings related to the these joints were determined (Table 2).

Table 2. Correlation between clinical and radiographic evaluations (correlation coefficient and significance (*P* values)

	CVJ	Exp	HGD	FIX	DD	MST	Pain	SIJ	MS	AIX	Age
CTJ	**0.81** **0.000**	**−0.61** **0.001**	0.34 NS	0.33 NS	0.23 NS	**−0.46** **0.02**	0.15 NS	**0.71** **0.000**	0.26 NS	**0.46** **0.02**	0.04 NS
CVJ		**−0.58** **0.002**	0.27 NS	0.22 NS	**0.44** **0.02**	**−0.45** **0.02**	0.07 NS	**0.82** **0.000**	0.12 NS	0.18 NS	0.33 NS
Exp			**−0.66** **0.000**	**−0.61** **0.001**	−0.18 NS	**0.54** **0.005**	−0.06 NS	**−0.40** **0.04**	−0.20 NS	**−0.42** **0.03**	−0.05 NS
HGD				**0.61** **0.001**	0.009 NS	**−0.49** **0.01**	−0.11 NS	0.23 NS	0.35 NS	0.15 NS	0.03 NS
FIX					−0.02 NS	**−0.40** **0.04**	**0.38** **0.05**	0.15 NS	**0.60** **0.001**	**0.66** **0.000**	−0.07 NS
DD						−0.27 NS	−0.09 NS	**0.45** **0.02**	0.02 NS	0.04 NS	**0.71** **0.000**
MST							−0.03 NS	**−0.42** **0.03**	−0.27 NS	−0.37 NS	−0.09 NS
Pain								−0.08 NS	**0.45** **0.02**	**0.57** **0.002**	−0.35 NS
SIJ									−0.03 NS	0.11 NS	0.34 NS
MS										**0.58** **0.002**	−0.19 NS
AIX											−0.20 NS

NS, not significant.
CTJ, costotransverse joint; CVJ, costovertebral joint; Exp, chest expansion; HGD, handground distance; FIX, functional index; DD, duration of disease; MST, modified Schober's test; SIJ, sacroiliac joint; MS, morning stiffness; AIX, articular index.

There was a significant correlation between the severity of involvement of SI and CV joints with the duration of disease. Both articular and functional indices showed a significant association with pain severity, duration of morning stiffness and chest expansion (Table 2).

Twelve patients (48%) described thoracic pain. Nine described pain on the anterior thorax, two of them having pain laterally and one posterolaterally. The pain was manifested in three patients during deep breathing, in four patients while coughing, and in five cases the pain was present in both situations. There was no significant difference between the two groups of patients with or without thoracic pain, according to the radiographic severity of CV, CT and SI joints, chest expansion, functional index, severity of pain and articular index. Moreover, there was no significant difference between these groups in terms of vital capacity and other pulmonary function tests.

The results of pulmonary function tests are given in Table 3. VC predicted values were found to be higher than FVC predicted values in all cases. Neither obstructive nor restrictive respiratory function abnormalities were detected in the pulmonary function tests. We observed no significant correlation between pulmonary function tests and any of the following variables: severity of involvement of the CT and CV joints, reduction of chest expansion, handground distance, or functional and articular indices. Nevertheless, a correlation of modified Schober's test with pulmonary function tests was detected (Table 4).

Discussion

We propose that investigating the changes to CV joints in AS would help us to understand the anatomical basis of some thoracic symptoms frequently manifested in these cases. In previous evaluations of the pulmonary involvement in AS patients spirometry showed restrictive changes, with a decreased vital capacity but a normal forced 1-s expiratory volume [6]. Sivri et al. [8]

Table 3. Results of pulmonary function tests

Pulmonary function test	Mean ± SD	Min-max	Predict value (mean ± SD)	Predict value (min-max)	Percentage of normal
VC (l)	3.5±0.7	2.4–4.8	4.31±0.7	3.17–5.64	82.8
FVC (l)	3.1±0.6	2.1–4.3	4.18±0.7	2.87–5.40	74.1
FEV_1 (l)	2.9±0.6	2.0–4.2	3.49±0.5	2.67–4.59	83.7
FEV_1/FVC	94.2±4.3	88–100	122.59±2.3	100–131	116.6
PEF (l/min)	6.8±1.6	3.6–9.6	8.57±1.1	6.50–10.17	80.2

Table 4. Correlation between pulmonary function tests, costovertebral, costotransverse and sacroiliac joint involvement grade, modified Schober's test and disease duration

PFT	CVJ		CTJ		SIJ		MST		DD	
	CC	*P*	CC	*P*	CC	*P*	CC	*P*	CC	*P*
VC	−0.02	0.91	0.05	0.81	−0.07	0.74	0.56	0.005*	−0.39	0.05*
VC (%)	−0.10	0.64	−0.06	0.77	−0.22	0.29	0.50	0.01*	−0.04	0.83
FVC	−0.14	0.52	−0.03	0.86	−0.24	0.26	0.57	0.005*	−0.52	0.01*
FVC (%)	−0.33	0.12	−0.20	0.37	−0.46	0.02*	0.45	0.03*	−0.17	0.42
FEV_1	−0.09	0.66	−0.03	0.88	−0.17	0.44	0.53	0.01*	−0.50	0.01*
FEV_1 (%)	−0.24	0.27	−0.18	0.40	−0.37	0.08	0.57	0.005*	−0.23	0.28
FEV_1/FVC	0.37	0.09	0.14	0.52	0.48	0.02*	−0.33	0.12	0.20	0.37
PEF	0.07	0.73	0.02	0.91	0.05	0.80	0.23	0.30	−0.25	0.27
PEF (%)	0.08	0.70	0.05	0.79	0.11	0.60	0.10	0.65	0.06	0.78

* Statistically significant correlation.
CC, correlation coefficient; PFT, pulmonary function tests; CVJ, costovertebral joint; CTJ, costotransverse joint; SIJ, sacroiliac joint; MST, modified Schober's test; DD, duration of the disease.

determined that all AS patients with interstitial lung disease findings on high-resolution CT scans had respiratory symptoms and evidence of restrictive lung disease findings on pulmonary function tests. Nevertheless, it is reported that respiratory function abnormalities seen in AS are of both obstructive and restrictive type as well [9]. In our study we observed no obstructive or restrictive defects in pulmonary function tests. Vanderschueren et al. [10] suggested that spirometrically determined volumes were better preserved than respiratory muscle strength in AS, and it was speculated that the reduction in respiratory muscle strength might be due to intercostal muscle atrophy. This situation may be concerned with the compensation of chest respiration by the diaphragm. In our study no relationship was observed between pulmonary function and CV and CT joint affliction. However, patients with stiffer spines had a tendency to have pulmonary function tests within the lower limit of the normal range. The more the patient's spine stiffens the closer the pulmonary function is to the lower limit of the normal range. This might suggest that lumbar spine mobility might contribute to pulmonary function to some extent, possibly by affecting diaphragmatic breathing. This seems to indicate the compensatory role of the diaphragm on chest respiration in patients with AS.

The patients with a decreased modified Schober's test also had less chest expansion. Moreover, both modified Schober's test and chest expansion were associated with the computed tomography changes in SI, CV and CT joints ($P < 0.05$). Fisher et al. [3] detected a significant relationship between chest expansion and lumbar flexion and extension. Chest expansion is likely to be reduced and the cough mechanism may be impaired by CV joints being involved [2]. There is no doubt that chest involvement in AS is not limited to the CV and CT joints. There is also an increased rigidity and deformity of the thoracic spine and involvement of the costosternal, sternoclavicular and manubriosternal joints. All these factors will contribute to the rigidity and deformity seen in AS. The diaphragmatic breathing is important in patients with an already stiff chest who also have a stiff spine.

Fisher et al. [3] showed that there was an association between chest expansion and VC, and between VC and exercise tolerance (VO_{2max}). They found no association between chest expansion and exercise tolerance. Most of the patients with very restricted chest wall movements in their study were able to achieve satisfactory work capacities. They stated that neither VC nor exercise tolerance showed any correlation with duration of disease, thoracic kyphosis or ESR. In our study, in contrast to the findings of Fisher et al., a significant association could not be found between chest expansion and VC, but was observed between duration of disease and VC. There was also a significant association between the articular and functional indices and chest expansion (Table 2). In our study, restriction in chest expansion was related to the reduction in functional capacity, although the exercise tolerance of the patients was not included in the study ($P < 0.05$). The measurement of mobility in the lumbar area, rather than the measurement of chest expansion, may be more indicative in respect of pulmonary function. It might be useful to investigate pulmonary function when there is a limitation in spinal mobility.

The involvement of CV joints in 80% of the cases and CT joints in 60% of the patients in our radiologic evaluation (Table 1) in general agrees with reports of CV involvement in 82% to 93% by various authors in patients with AS suffering thoracic pain [2, 11]. In our study previously described bony bridges were not observed [2, 11]. A correlation between severity of involvement of the three sites (CV, CT, and SI joints) seems reasonable, and there was also a correlation between the severity of involvement of CV and SI joints and duration of disease. Pascual et al. [2] and Gener et al. [11] also observed that CT scans and plain X-ray findings in CV joints were increased with the duration of disease.

Pain occurring with compression of the lateral chest wall also indicates CV joint involvement [2]. Recently Le et al. [12] reported a case of AS with severe pain in

the thoracic spine area owing to a destructive arthropathy of a costovertebral joint. In addition, Benhamou et al. [13] stated that there might be pseudourologic pain with CV and CT joint involvement, owing to the anatomical relationship between CV joints and sympathetic communicating rami. We did not find a statistically significant difference between the patients complaining and those not complaining of chest pain in respect of the X-ray severity of involvement of SI, CV and CT joints ($P > 0.05$). As happens in other axial joints, similar changes may be found in the absence of pain [2].

After pain and stiffness, one of the most important complaints of patients with AS is disability. Thus, the assessment of daily vital function is of clinical importance. Various descriptive scales have been devised to measure overall functional capacity. In our study, we used the articular and functional indices described by Dougados et al. [7] to evaluate the functional capacity of the patients. A significant correlation was determined between chest expansion, morning stiffness and pain severity with these indices ($P < 0.05$). A significant relation was found between the modified Schober's test and handground distance with functional indices ($P < 0.05$). Although there was a progressive reduction in mobility in more than half of the patients with AS, our findings contradict the idea that functional results are satisfactory in general [6].

In conclusion, the clinical and radiological findings in CV, CT and SI joints in AS seem to be related to each other. The severity of involvement in CV and SI joints increases with duration of disease. Patients with stiffer spines have a tendency to have pulmonary function tests within the lower limits of the normal range. In patients with AS diaphragmatic breathing might compensate the chest respiration to some extent. Therefore, the assessment of pulmonary function may be suggested in cases where there is a limitation of spinal mobility, particularly in patients with a prolonged duration of AS.

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