

## ENVIRONMENTAL ASBESTOS DISEASE: PLEURAL PLAQUE VOLUME MEASUREMENT WITH CHEST TOMOGRAPHY IS THERE A CORRELATION BETWEEN PULMONARY FUNCTION?

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**ABSTRACT.** *Objectives:* Chest X-ray is correlated with pulmonary function of asbestos related disease. These correlations limited by low specific and sensitive. Computed tomography (CT) more sensitive. There was no adopted for the measurement of CT. Our aim in this study was to determine correlation between pleural plaque (PP) volume and lung function for use improving classification with CT. *Methods:* The study included 75 patients with environmental asbestos exposure. PP areas measured in patients were divided by the patient lung area to determine PP ratio with CT. Diffusing capacity and six minute walking distance (6MWD) measured and evaluated quality of life. Results: PP identified in 66 (88%) of the patients with CT. PP most frequently noted in the front right quadrant and had an average plaque volume of 7729,17 mm<sup>3</sup>. Plaque ratio taken as the percentage of the ratio to the lung volume, mean plaque percentage was 0,37±0,45% (0,003-2,3). In 12(18,1%) of the patients, asbestosis not seen with chest X-ray was detected with CT. *Conclusions:* PP volume and ratios were not statistically significantly correlated with respiratory functions, exercise capacity, cumulative amount of exposure. Patient of asbestos disease total lung capacity was lower, 6MWD distance was shorter and quality of life was poorer. (*Sarcoidosis Vasc Diffuse Lung Dis* 2017; 34: 336-342)

**KEY WORDS:** environmental, asbestos, quality of life, pleural plaque

### INTRODUCTION

Asbestos related disease is worldwide problem. Pleural plague (PP), asbestosis, malign mesothelioma, pleural effusion, diffuse pleural thickening and bronchogenic carcinoma of conditions of asbestos related diseases. The most common manifestation of

asbestos related disease PP. Detection of early pleural asbestos and parenchymal changes computed tomography (CT) are more sensitive than chest X-ray. Chest X-ray correlated respiratory function, cumulative amount of exposure These correlations allow sensitive and specificity detection of early pleural and parenchymal changes. There was no adopted for the measurement of CT is an International Labour Organization (ILO) classification. Standard CT protocol is related to high radiation dose. These protocols increased concern about potential malignant disease. A few studies (lung cancer screening programs) have been reported usefulness of low dose CT for mediastinal structures, abnormalities (1-6). Multi detector spiral CT created opportunities screening in terms high spatial resolution and low dose radiation.

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Our aim in this study was to determine correlation between pleural plaque volume and lung function for use improving classification with CT.

## METHODS

### *Study population*

The soil around the Denizli region contains tremolite asbestos (7). The study included 75 patients who had radiological findings consistent with environmental asbestos exposure as defined by Chest X-ray. Patients who had none of the exclusion criteria listed below were admitted to the study after they have read and signed the informed consent form.

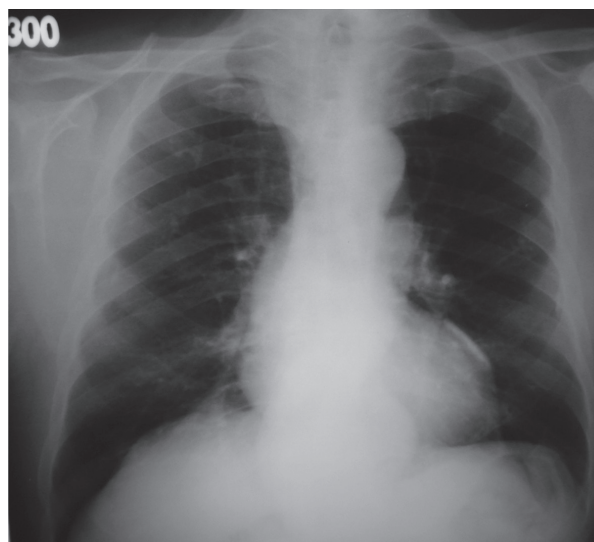
### *Exclusion criteria*

Clear contraindications for 6MWD were history of instable angina or heart attack during the last one month and clear contraindications for diffusion test were chest or abdominal pain for any reason, increased oral or facial pain or deformity associated with mouthpiece, stress incontinency, dementia and confusion.

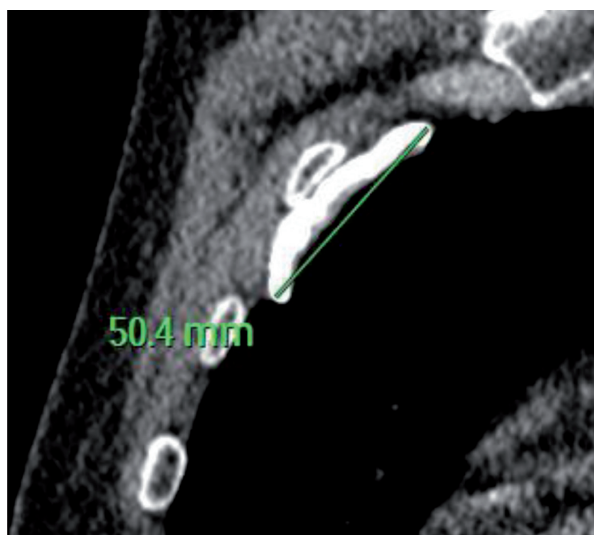
### *CT Examinations and interpretation of CT images*

CT scans performed using a 16-lead instrument (Briliance CT 16 v2.00 Philips Medical Systems). Patients were in supine position and holding breath, sections from the lung apex to costophrenic sinuses were scanned. Intravenous (iv) contrast agent was not administered to the patients for this investigation. The following low-dose investigational parameters applied: kV 120, mAs 30, collimation 16x1,5 mm, section thickness of 1 mm, reconstruction range 0,5 mm. Once the scan was complete, all the images were reconstructed using soft a tissue and a bone filter. Images were then loaded to the workstation (extended Brilliance Workspace v3.5,0 Philips Medical Systems). Each of the obtained images evaluated by a radiologist, experienced in chest CT, from the radiology department. PP divided into 4 quadrants (front right, rear right, front left, rear left) in the axial plane for evaluation. Quadrants divided at the esophageal line in the axial plane. The longest diameters of the PP in these 4 quadrants were taken individually and the

values recorded. (Figure 1) Longest diameters of both hemidiaphragmatic PP and pericardial plaques measured at 3 axis and the values were recorded. Lung volumes taken as the longest diameter in the axis measured and recorded (Figure 2). Craniocaudal distance was measured from the tracheal line in the coronal plane, and transverse and anterior-posterior distances were measured at the right mid lobe bronchi branching line in the axial plane. PP volume measured was divided by lung volume to determine PP ratio.



**Fig. 1.** Diaphragmatic plaques on the right and pericardial calcified pleural plaques on the left with lung radiography



**Fig. 2.** Measurement of the longest diameter of the asbestos plaque at the coronal plane

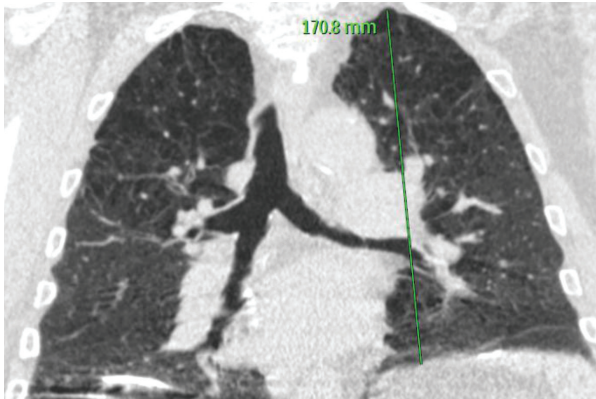


Fig. 3. Measurement of craniocaudal length at the coronal plane

#### *Six minute walking distance*

Six minute walking test according to the recommendations of American Thoracic Society's guidelines performed to evaluate exercise capacity (8).

#### *Diffusion capacity*

Diffusion capacity measurements were performed using the single-breath method.

#### *Quality of life*

Short Forms (SF 36) developed by Ware et al used (9). SF-36 is used in the analyses of individuals with chronic disease and of the public health. Subscales grade health from 0 to 100, with 0 indicating poor health status and 100 indicating good health status.

#### *Statistical evaluation*

Statistical analyzing was performed using by Windows-based SPSS statistical software. Chi square analyses were used to compare nominal variables: In the analyses of quantitative data, parametric analyses (t tests, ANOVA) were used for the variables that were fit for normal distribution and non-parametric analyses (Mann Whitney U, Kruskal Wallis) were used for the variables that were not fit for normal distribution. P 05 was considered indicate significance.

## RESULTS

### *Radiologic findings*

Pleural plaques due to environmental asbestos exposure were found in 66 of the 75 patients with chest CT. In most of the 9 patients without plaques in CT, calcified lesions accidentally assessed as plaques. Six of these patients had findings which could represent a pleural plaque-like calcified appearance with Chest X-ray. 66 patients plaques were observed, 64 (96,6%) costal plaques, 44 (66,6%) diaphragmatic plaques, and 9 (13,6%) pericardial plaques. PP most frequently was front right quadrant and had an average plaque volume of 7729,17 mm<sup>3</sup>. There were no significant correlations between plaque volume and time passed since the first exposure or cumulative amount of exposure. Plaque ratio taken as the percentage of the ratio to the lung volume, mean plaque percentage was  $0,37 \pm 0,45\%$  (0,003-2,3). The comparison of plaque ratio percentages showed no significant difference between females and males ( $p > 0,05$ ). Asbestosis was identified in 12 (18,1%) of the patients

### *Respiratory function results*

44 patients were able to complete the diffusion capacity test. Their mean DLCO (mmol/kPa/min) was  $5,67 \pm 1,67$ , %DLCO was  $89,97 \pm 20,79$ , DLCO/VA (mmol/kPa/min/l) was  $1,38 \pm 0,39$ , and %DLCO/VA was  $90 \pm 20,78$ . A statistically significant correlation was not observed between plaque volume and DLCO% ( $p > 0,05$ ). Plaque ratio percentages and DLCO (mmol/kPa/min), %DLCO, DLCO/VA (mmol/kPa/min/l), %DLCO/VA, FRC(l), %FRC, TLC(l) and %TLC were not had statistically significantly correlated ( $p > 0,05$ ). Patients with asbestosis statistically significantly lower TLC ( $p < 0,05$ ). The result of the diffusion test are shown in table 1. 6MWD could not be performed for 13 of the 66 patients with asbestos plaque due to an orthopedic condition. 53 patients had mean walking distance  $369,85 \pm 102,43$  (140-720) meters. A statistically significant decline was observed in percentage saturation following 6MWD compared to baseline saturation (Table 2) ( $p < 0,05$ ). After 6MW test, a statistically significant increase in heart rate (pulse/min), in dyspnea scale compared to baseline value ( $p < 0,01$ ). Plaque volume, plaque ratio and walking distance were not statistical-

**Table 1.** Diffusion test results of patients with asbestosis

	Without asbestosis (n:24)	With asbestosis (n:6)	p
DLco (mmol/kPa/min)	5,85±1,82	5,02±0,88	NS
%DLco	89,17±22,44	93,17±13,21	NS
DLco/VA (mmol/kPa/min/l)	1,37±0,42	1,40±0,26	NS
%DLco/VA	89,21±22,43	93,17±13,21	NS
FRC (l)	3,06±0,72	2,55±0,47	NS
FRC (%)	99,67±17,72	92,17±13,84	NS
RV (l)	2,19±0,59	1,99±0,27	NS
RV (%)	97,33±22,71	93,67±14,50	NS
RV/TLC (%)	49,21±11,08	52,83±5,56	NS
TLC (l)	4,48±0,81	3,80±0,69	p<0,05*
TLC (%)	86,29±15,26	96,67±20,92	NS

NS: Not significant, \*Mann-Whitney U test

**Table 2.** 6MWT comparison of patients with asbestosis

	Without asbestosis (n:46)	With asbestosis (n:7)	p
Walking distance	380,96±102,68	96,86±68,50	p<0,05*
Amount of increase in dyspnea scale after 6MWT	2,65±0,99	3,57±1,27	NS
Amount of increase in heart rate /min after 6MWT	18,95±14,96	27,42±14,54	NS
Amount of decrease in saturation after 6MWT	0,82±2,26	1,71±5,52	NS

NS: Not significant, \*Mann-Whitney test

**Table 3.** Comparison of mean quality of life scores of patients with and without asbestosis

	Without asbestosis (n:54)	With asbestosis (n:12)	p
Physical functioning score	59,26±30,36	33,33±23,86	p<0,01*
Physical role difficulty	55,09±46,42	8,33±22,19	p<0,01*
Pain	59,20±31,98	31,17±22,70	p<0,01*
Overall health perception	50,31±19,69	31,58±21,97	p<0,05*
Vitality	48,89±24,60	28,33±14,82	p<0,05*
Social functioning	72,25±24,59	69,66±38,96	NS
Emotional role difficulty	70,36±41,39	16,67±38,92	p<0,01*
Mental health	61,26±19,07	47,02±0,61	p<0,05*

NS: Not significant, \*Mann-Whitney test

ly significantly correlated. Mean 6MWD of patients with asbestosis was statistically significantly shorter compared to those without asbestosis.

### Quality of life

Subscales of quality of life compared by sex, males had statistically significantly higher scores than females (Table 3). PP volume, plaque ratio and quality of life alt subscale scores were not statistically significantly correlated. Patients with asbestosis demonstrated statistically significant differences in all subscales except the social functioning subscale.

## DISCUSSION

*Pleural plaque volume measurement with chest tomography is there a correlation between pulmonary function?*

Chest X-ray is used in pneumoconiosis classification of ILO (10). PP due to asbestos exposure irregular and occur on the diaphragm or through the edge of the lung side. Chest X-ray fail short especially in demonstrating the paravertebrally and posterior parts of the costal pleura and in revealing initial interstitial fibrosis. CT is superior in demon-

starting diseases associated with asbestosis but there is no acknowledged classification with CT. There are a number of studies proposing classifications that can be used with CT in individuals with asbestos exposure. Meirelles et al. recommended a semiquantitative PP scoring system (11). HRCT was used in this scoring system. PP was examined by dividing into 4 quadrants in the axial section. PP was grouped by size (A1: less than 50% of the quadrant and thickness less than 5 mm, A2: less than 50% of the quadrant and thickness more than 5 mm, B1: more than 50% of the quadrant and thickness less than 5 mm, B2: more than 50% of the quadrant and thickness more than 5 mm) and was scored, and sum of the pleural scores from approximately 20 sections taken. Diaphragmatic plaques scored were by dividing the number of tomographic sections where the plaque visible by the number of tomographic sections where the diaphragm visible. Because this scoring system uses HRCT, it is a source of high-dose radiation and given the skip-based imaging, estimation of plaque dimensions is semiquantitative. The relationship of this staging with patients' respiratory function and exercise parameters, however, was not investigated. Aberle et al. proposed a classification by conventional CT and 5 additional HRCT sections from the basal lung in patients with asbestos exposure but the authors not perform an interobserver and intraobserver evaluation for the classification (12). A classification reported by Schwartz et al. determined a decrease in restrictive lung functions (TLC) with pleural fibrosis, but this classification requires dedicated software and workstation and is expensive and time consuming (13). Kraus et al. published a pneumoconiosis classification with HRCT but the classification is complicated and requires a trained radiologist (14). Van Cleemput et al. proposed a classification which calculates total lung plaque area by measuring the area of asbestos plaque, where asbestos plaque measurements may be subject to variation due to sectional nature of the CT (15). Jarad et al. proposed a scoring with CT using 3 mm sections and 10 mm interval in 20 patients with 20 asbestos exposure. This system suggests a scoring system that not just addresses to plaques but also enables evaluation of PP, fibrosis and asbestosis findings together (16). A relationship between respiratory functions was identified in the classification proposed in this study. This is because the scoring system are affected to a higher extent

from fibrosis and parenchymal changes than PP. Besides, the study group that had a higher occupational asbestos exposure had a higher fiber load. Most of the patients in our study group would be stage 1 or 2 with this scoring and stages 3 and 4 would be very few.

Our study involves quantitative volume measurement of PP with non-sectional CT and taking its ratio to the lung volume. Effect of PP not similar, because of lung volume of patient different. The previous study did not assess lung volumes. Therefore, our study differs from previous studies, there was no correlation between the 6MWT, pulmonary function and quality of life impact.

#### *Demographics*

PP is known to be associated with the time passed since the first exposure, rather than the contacted dose. In a population based study, the incidence of PP reported to rise from 0.2% in 1965 to 2.7% in 1985 in individuals aged above 40 years in Uppsala, Sweden (17). In our study, mean age of patients who were found to have plaques was 71 years. Of the patients with plaques in our study, 8 (12,1%) were aged 50-60 years, 18 (27%) were aged 60-70 years, 32 (48 were aged) were aged 70-80 years, 8 (12,1 were aged) were aged 80-90 years. The youngest and oldest patients for whom plaque was identified were aged 53 and 89 years, respectively.

#### *Characteristics of plaques*

Järholm et al, reported in their review that the sensitivity of pulmonary radiography was below 50%, in comparison with CT, in detecting pleural plaques (18). With Chest X-ray easy to detect large and thick plaques but difficult to detect costal plaques and those which are close to the vertebra. In our study, asbestos plaques were detected in 66 patients (88%) with low-dose CT taken for 75 patients. The patients with no plaques with CT findings in chest X-ray that could be confused with pleural plaque such as calcified sequelae fibrotic, calcified granuloma. In our study, the majority of the plaques wbilateral (90,9%), followed by right (6%) and left (3,1%) sided plaques, respectively. The most frequently involved site of pleural plaques chest wall (96,6%), followed by diaphragmatic plaques (66,6%) and pericardial plaques (13,6%).

### *Asbestosis*

Chest x-ray results reported in 6 patients (10%) in a study with 58 patients with asbestosis diagnosed with lung biopsy, and another study identified no direct radiological evidence in 25 (18%) of 138 patients with asbestosis with histopathologically-established lung fibrosis (21-22). Gevenois et al. reported that CT could detect early pleural and parenchymal changes before clinical evidence occurs (23). A study by Aberle et al reported high resolution CT findings in about 20-30% of the patients with normal chest X-ray (12). In our study, asbestosis was in the early stage and therefore asbestosis was not detected with Chest x-ray.

### *Respiratory functions*

PP surface areas and patient's respiratory functions did not yield a relationship (15). Similar to the result of our study, no relationship between pleural plaque volume and respiratory functions.

### *Diffusion capacity*

Abejie et al. reported that patients with asbestosis findings lower diffusing capacity lung carbon monoxide (DLCO) values compared to those without asbestosis findings (24). A study with patients with environmental asbestos exposure evaluated patients' radiological findings with high resolution CT and found DLCO to be within normal ranges in the group of patients interpreted to have early asbestosis, whereas there was a pronounced decrease in the group with evident asbestosis and fibrosis (25). In our study, the total lung capacity (TLC) was lower in patients with asbestosis. DLCO and DLCO/VA (diffusing capacity lung carbon monoxide/alveolar volume) was not different between pleural plaque patients with and without asbestosis. In our study asbestosis was early stage.

### *Exercise capacity*

There are no studies investigating the effect of asbestos exposure on exercise capacity. In this study, patients' mean walking distance was 420 meters (26). Manali et al. found a mean walking distance of 326 meters in patients with idiopathic pulmonary fibrosis (27). Lama et al reported that desaturations in

6MWT was a strong indicator of mortality in patients with interstitial pulmonary disease (28). In our study, mean walking distance was measured as 399 meters in males and 328 meters in females. In our study, patients' dyspnea scale, heart rate /minute count increased and saturation decreased after the test, with a statistically significant difference between pre- and post-test values.

### *Quality of life*

There are a few studies evaluating the effect of asbestos exposure on quality of life. Chang et al. reported that the short form 36 quality of questionnaire was sensitive and practical in interstitial lung diseases (29). In our study, physical functioning, pain, physical role difficulty, general health perception, vitality, mental health subscales of quality of life were lower in 12 patients with asbestosis compared to patients without asbestosis.

## CONCLUSION

Pleural plaque volume and ratios were not statistically significantly correlated with respiratory functions, exercise capacity, cumulative amount of exposure. Patients with environmental asbestos exposure low 6MW distance, as in other chronic conditions, when calculated according to the formula proposed for the healthy population. Our study also evaluated patients quality of life with the SF-36 questionnaire and found that their life quality was affected. In 12 of the patients, asbestosis not seen with Chest X-ray was detected with CT. Patients with asbestosis TLC (ml) lower, 6MW distance shorter and quality of life was poorer than patient with asbestos.

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