THE FACTORS THAT AFFECT RESTRICTIVE SPIROMETRIC ALTERATIONS IN SILICOSIS PATIENTS WORKING IN DENIM SANDBLASTING

KOT TAŞLAMA İŞİNDE ÇALIŞAN SİLİKOZİSLİ HASTALARDA RESTRİKTİF SPİROMETRİK DEĞİŞİKLİKLERİ ETKİLEYEN FAKTÖRLER

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SUMMARY

Aim: *Silica used in denim sandblasting is current source of silicosis that cause tragic consequences especially in Turkey in recent years. This preventable but incurable disease that is so endemically widespread among the denim sandblasting workers which exposed for a long time in unhealthy conditions, had a great impact on international public health platform. In our study were aimed to determinate the factors that effect restrictive pattern in sandblasting releated silicosis.*

Material and Methods: *In our study were evaluated the demographic,spirometric, laboratory, clinical and anamnestic findings of the patients who had silicosis due to denim sandblasting and were evaluated at various levels of disability for restrictive respiratory failure secondary parenchymal damage evolving.*

Results: *The restrcitive pattern indicators correlated with the onset age of exposure to silica and areas of workplaces positively, with exposure duration and serum neutrophil / lymphocyte (N/L) ratio negatively, in study evaluated 21 patients with silicosis, all male and with the average age 20.4 years.*

Conclusion: *According to datas of our study, early onset of silica exposure, long exposure time,*

ÖZET

Amaç: *Kot taşlama işinde kullanılan silika, son yıllarda özellikle Türkiye'de trajik sonuçlara neden olan güncel bir silikozis kaynağıdır. Sağlıksız koşullarda uzun süre silikaya maruz kalan kot taşlama işçilerinde endemik olarak görülen önlenebilir fakat tedavi edilemez bu hastalık, uluslararası platformda büyük yankı uyandırmıştır. Çalışmada kot taşlamayla ilişkili silikoziste, restriktif patterne etki eden faktörlerin değerlendirilmesi amaçlanmıştır.*

Yöntem ve Gereç: *Çalışmamızda kot taşlama işine bağlı silikozis gelişen ve parankimal hasara sekonder restriktif solunum yetmezliği nedeniyle çeşitli derecelerde maluliyet almış olguların demografik, spirometrik, laboratuar, klinik ve anamnestik verileri değerlendirilmiştir.*

Bulgular: *Tümü erkek ve yaş ortalaması 20.4 yıl olan 21 silikozisli olgunun değerlendirilmiş olduğu çalışmada restriktif patern göstergelerinin silikaya maruziyete başlama yaşı ve çalışılan işyeri alan büyüklüğü ile pozitif, maruziyet süresi ve serum nötrofil/lenfosit oranı ile negatif yönde korele olduğu saptanmıştır.*

Sonuç: *Çalışmamızın verilerine göre silika maruziyetine erken başlamanın, uzun maruziyet süresinin, küçük iş yerinde çalışmanın kot taşlama işine*

work in smaller workplace is thought to be a poor prognostic value for restrictive pattern in patients with silicosis due to denim sandblasting. High N / L ratios is very useful for monitoring the systemic effects of the disease.

bağlı silikozis gelişen hastalarda restriktif patern açısından kötü prognostik değerler olduğu düşünülmektedir. Yüksek N/L oranları, hastalığın sistemik etkilerini monitorize etmede oldukça yararlıdır.

INTRODUCTION

Silicosis is an untreatable but preventable occupational pulmonary disease known since the ancient times (1). The disease is characterized by production of proinflammatory/ profibrotic mediators in response to free crystalline silica inhalation, persistent inflammatory response and diffuse interstitial alternations (2,3). It is common among workers of tunnel construction, mining and silica extraction due to inevitable exposure to silica-containing minerals present in each layer of the earth's crust, although other sporadic, previously unknown sources of silica, in addition to these well-known sources which are now more strictly controlled, have also been identified (4,5). Cases of silicosis associated with fine powders used in matting manufacture with dry hot sludge in China (6) and with quartz and cristobalite contained in filling materials in dental supply plants in the USA (7) have been demonstrated. However, the origin of silicosis, which gave the disease its current prominence has been reported from the Turkish textile industry – silicosis associated with denim (jean) sandblasting (1). Denim sandblasting is a process that uses sand which contains silica as the abrasive to give the denim a "worn-out" appearance (8). This industry involves very poor hygienic conditions with no or very poor respiratory protection and prolonged working hours, resulting in heavy exposure. It is there acknowledged as the most dangerous of the known sources of silica (1). Following the reporting of the first case in Turkey in 2003 (9), there has been a dramatic increase in the number of cases reported as well as a remarkable improvement in the body of knowledge on the factors that determine the prognosis. To contribute to the current body of knowledge, the present study evaluated the anamnestic and demographic factors that are involved in the spyrometric alternations in individuals working in denim sandblasting diagnosed with silicosis with varying degrees of disability due to restrictive respiratory impairment.

MATERIAL AND METHOD

The present study included individuals with no pre-existing health problems, who have been working in denim sandblasting for a defined period of time, who were diagnosed with silicosis by radiological, clinical and spyrometric methods and for whom varying degrees of disability with restrictive respiratory impairment have been established. Based on international standards, FVC measurements below 80% were considered as "Restrictive Respiratory Impairment"(10).

Laboratory Findings: Blood samples (2 cc) were collected in EDTA-containing tubes from the subjects for neutrophil and lymphocyte measurements. The blood samples were analyzed in the laboratory using the Counter LH780 instrument with the Laser method. Neutrophil/lymphocyte ratios (N/L) were calculated based on serum neutrophil and lymphocyte measurements and the results were recorded.

Spirometric Findings: Spirometric measurements (Forced Vital Capacity (FVC), %FVC, Forced Expiratory Volume in first second (FEV1) and FEV1/FVC) were performed using Spirolab Mir type instrument. Expected lower limits for FVC in millilitres based on age, height, body weight and gender were

calculated for each subject. The value obtained after subtracting the actual FVC from the value as calculated above was considered as the "Total losed FVC" and was used along with FVC and %FVC values to evaluate the process by which the disease progressed to the restrictive pattern.

Workspaces: The size as (m^2) and the air condition status of workspaces of each workers were asked and recorded.

The subjects were questioned for the age they started and quitted their jobs, their working times, the size of the area where they performed denim sandblasting and history of respiratory complaints. All the obtained data were used in statistical analyses.

Statistical Analysis

Statistical analyses of the study were performed at the Biostatistics Department of the Medical Faculty of Uludağ University using the SPSS 13.0 package software. Correlations between individual parameters were analyzed using Pearson Correlation Analysis. The results were expressed as mean ± standard deviation (SD). Statistical significance was set at $p < 0.005$.

RESULTS

In the present study, 24 individuals who were either relatives or close friends who used to work in denim sandblasting, diagnosed with silicosis by clinical, pathological and radiological methods and classified as disabled due to restrictive respiratory impairment were evaluated in Karlıova district of Bingol city, where they resided. Twenty-one subjects used to work in Istanbul, while the remaining three refused to disclose the name of the city they used to work for various reasons.

Three of these individuals were excluded from the study. One of them was kyphoscoliotic to an extent that could contribute to restrictive respiratory impairment. Two had infections (one tonsillitis, one sinusitis) that could affect serum neutrophil and lymphocyte measurements. There was no differance about comorbid disease, smoking habit, the air condition status of workspaces, the preventive measures, BMI, weight and other findings. Data of 21 subjects included in the study with a median working period of 40.2 months (range: 6-60 months) and median age of 20.3 years (range: 19-22 years) are presented in Table 1.

FVC values were positively correlated with the size of workspace ($r=0.601$ and $p=0.002$) and with age at start of employment ($r=0.471$ and $p=0.023$). Monthly working time ($r=-0.414$ and $p=0.049$) and N/L ratio ($r=-0.454$ and $p=0.030$) were negatively correlated (Figure 1-4).

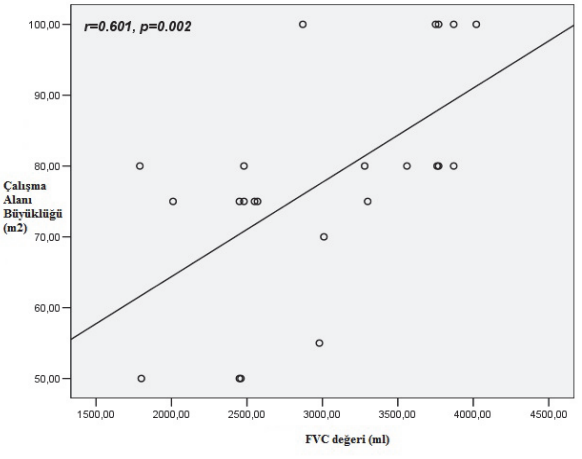

Figure 1. The correlation between areas of workplaces and FVC values

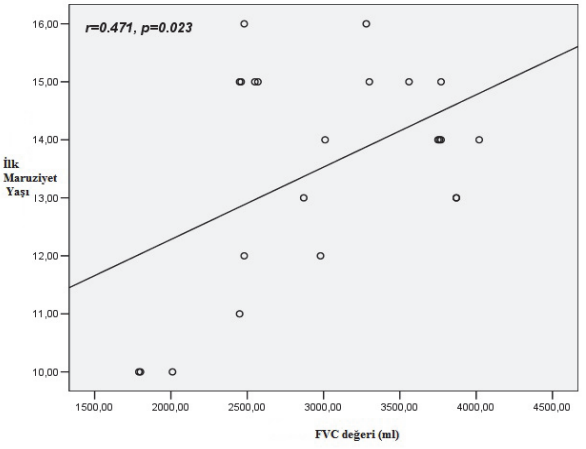

Figure 2. The correlation between first exposure age and FVC values

Table 1. Demographic datas of the patients.

±SD	Mean Values	Minimum Values	Maximum Values
Age (year)	20.4±0.9	19	22
FVC (ml)	2993.5	1790	4020
%FVC	62.5	41	75
FEV1(ml)	2650.8	1270	4460
FEV1/FVC	76.9	65	99
Losed FVC (ml)	872.2	443	1671
Work Onset Age (year)	13.5	10	16
Work Stopping Age (year)	16.9	15	19
Yearly Work During (hour)	8598.1	1100	16992
Monthly Work During (year)	40.2	6	60
Neutrophil/Lymphocyte Ratio	1.89	1.55	2.31

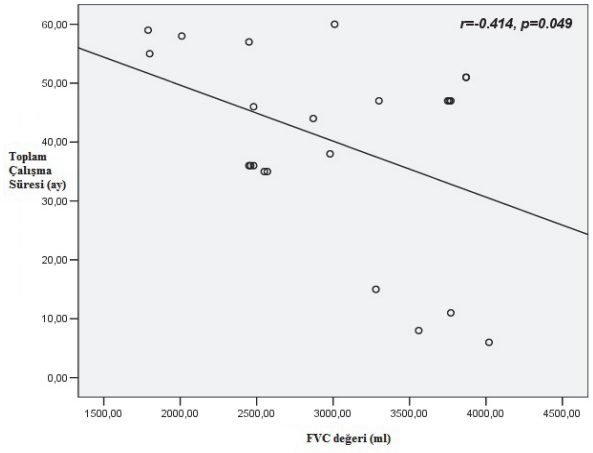

Figure 3. The correlation between monthly duration of working and FVC values

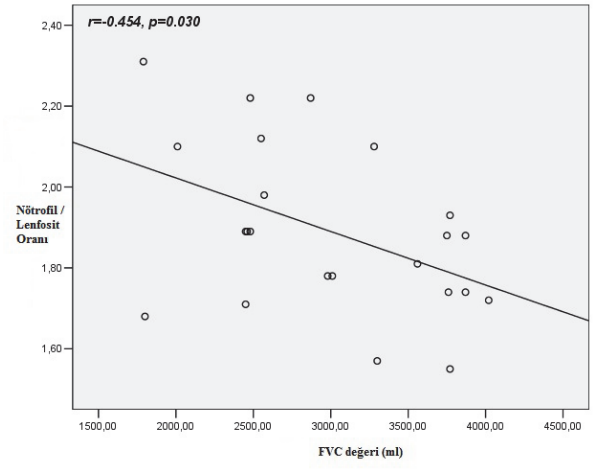

Figure 4. The correlation between N/L ratio and FVC values

%FVC values were positively correlated with the size of workspace (r=0.430 and p=0.041) and with age at start of employment (r=0.600 and p=0.002). There was a negative correlation between monthly working time (r=-0.427 and p=0.042) and %FV values (Figure 5-7).

Total losed FVC values were negatively correlated with the areas of workplaces (r=0.424 and p=0.044) and with onset age of employment (r=0.540 and p=0.008), while positively correlated with the N/L ratio (r=0.423 and p=0.045) (Figure 8-10).

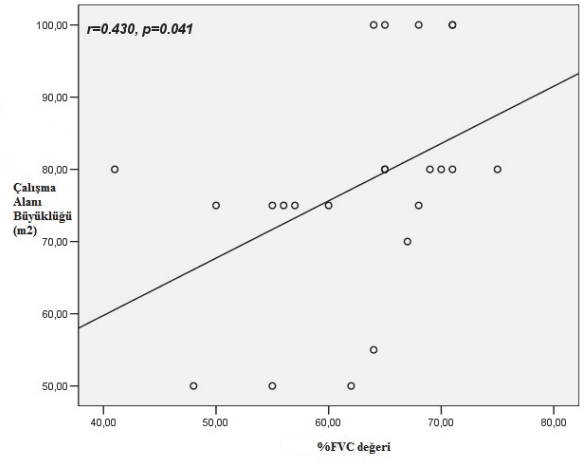

Figure 5. The correlation between areas of workplaces and %FVC values

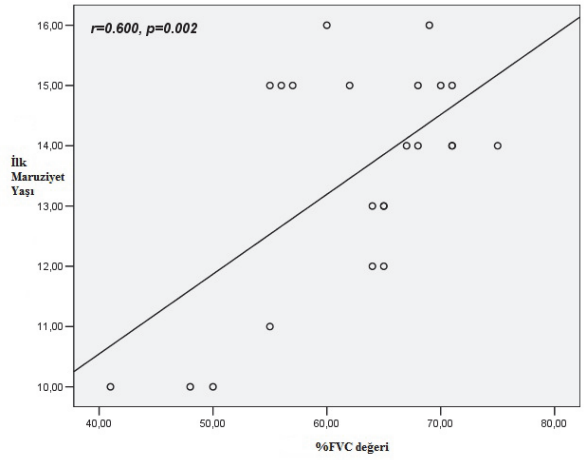

Figure 6. The correlation between first exposure age and %FVC values

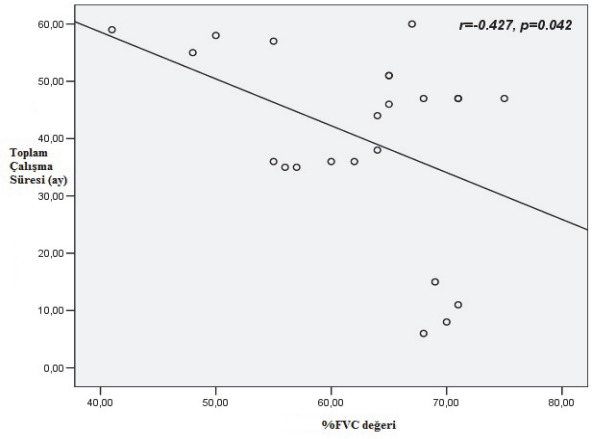

Figure 7. The correlation between monthly duration of working and %FVC values

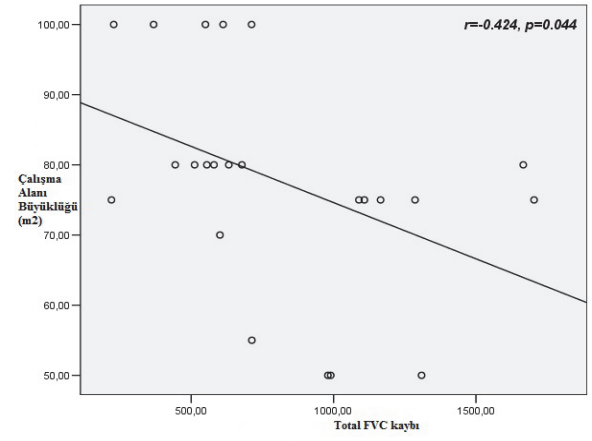

Figure 8. The correlation between areas of workplaces and total losed FVC values

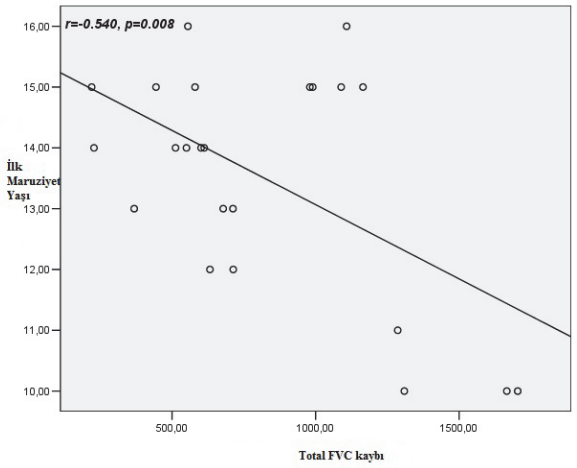

Figure 9. The correlation between first exposure age and total losed FVC values

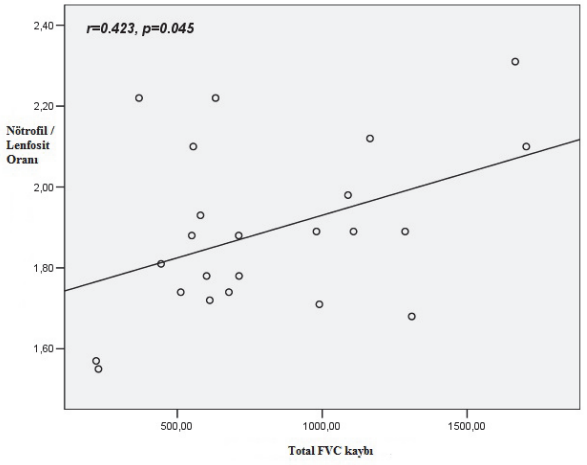

Figure 10. The correlation between N/L ratio and total losed FVC values

DISCUSSION

Despite the declined prominence as a result of the banning of silica processing in Europe long ago (11), silicosis has become an important healthcare concern in Turkey, particularly in the last decade, with cases presenting with the disease secondary to denim sandblasting. Denim sandblasting is a process by which sand particles are sprayed over the fabric via pressurized air or steam to abrade the denim to soften the fabric or give it a lighter colour (1). For this purpose, quartz, which is a cheap and readily-available kind of

mineral, is utilized in Turkey (9). Silica is one of the major environmental factors known to induce autoimmune dysfunction, which results in alternations in the parenchyma that lead to fibrosis (12,13). Although the dose-response relationship of silica is already known from earlier experimental animal studies (14), there are increasing number of recent studies reporting a positive correlation between the likelihood of developing silicosis and cumulative exposure to silica powder in man (15,16). Major studies on this topic have demonstrated associations of dose-response relationship with working duration (17,18), age at first exposure (18) and cumulative exposure (19) in silicosis-related mortality. Because pneumoconiosis is usually characterized by progressive parenchymal lesions, it is recommended to use FVC as the disease indicator which suggests restrictive respiratory impairment (3,20). FVC, %FVC and total losed FVC values were therefore used as indicators of disease severity in the present study. Our analyses demonstrated positive correlation between FVC and %FVC values and subjects' age at start of employment, and a negative correlation with total losed FVC values. Our results support the overall data from previous studies demonstrating a linear relationship between the restrictive severity of silicosis and age at start of employment. The negative correlation between monthly working time with FVC and %FVC values was another finding of the present study that confirmed the cumulative dose-response relationship of silicosis.

Given that the particle concentration an individual is exposed is a critical parameter in silicosis development and its progression, it is evident that the size of the workspace would present an important factor besides the time of exposure to the silica powder in terms of silicosis development. Major studies on this topic have concluded that the size of the workspace where the procedure is being carried out was a key factor that affects particle concentration (9,21); the smaller the workspace, the worse the disease progression secondary to the increased particle concentration being exposed. This leads to spyrometric alternations predominant in the restrictive pattern. Therefore, the sizes of the workplaces in square metres (m2) where the subjects performed the denim sandblasting procedure were questioned. The statistical analysis revealed a positive correlation with %FVC and a negative correlation with total losed FVC of the parameters studied for the influence of workplaces size on restrictive weight. These data all emphasize strongly the important role of workplaces size in the severity of silicosis associated with denim sandblasting.

Although noticeable impacts of silica inhalation are observed in the lung parenchyma, these changes are a result of a systemic cascade. Exposure to high doses of silica has been associated with damages in pulmonary surfactant mechanism and interference with receptor levels, induction of reactive oxygen radical production which directly or indirectly leads to cytokine synthesis, and with increased lysosomal permeability (22). These processes are followed by systemic autoimmune dysfunction which leads to production of proinflammatory and profibrotic factors which are responsible for the progressive course and parenchymal alternations (2,3). It is possible to monitor the systemic effects of disorders like silicosis. Whether there is a parameter that is easy to measure and indicative of the severity in systemic inflammations has been an investigational topic for a long time. One of the most interesting of these parameters is the serum neutrophil-lymphocyte ratio. Reliable markers of systemic inflammation and stress that are easy to measure have been reviewed in critical patients with shock, multiple trauma, sepsis and following major surgery. The study concluded that the N/L ratio was one of the leading parameters that has been most widely investigated for this function and that has been shown to be reliable. Another conclusion of the study was that this ratio had a prognostic value in measuring the level of stress in intensive care patients and in their monitoring (23). Another study identified a significant increase in N/L ratios in case control studies in Chronic Fatigue Syndrome

(CFS), which is a systemic inflammatory disease (24). In patients with COPD, N/L ratios of hypercarbic and acidotic subjects were higher compared to non-hypercarbic and non-acidotic subjects, and serum N/L ratios monitored following angioplasty was a very effective indicator of long-term mortality in coronary heart disease, and this was attributed to the systemic inflammatory effects of the disorder (25,26). In our study, the N/L ratio, as a parameter which has a linear relationship with the severity of systemic inflammation, was negatively correlated with FVC values and positively correlated with total losed FVC values. We concluded that these data contribute to the information derived from the previous studies that serum N/L ratio may be used to easily monitor the systemic process involved in this disease.

Patients with restrictive spyrometric findings only were evaluated in the present study. However, silicosis is a disorder that may have other presentations than the restrictive pattern. Obstructive or mixed type impairments may also be observed in some patients, although these represent a small minority. Since these two types of patients were not evaluated, the study may be limited in terms of a global overview of silicotic individuals and their demographics, which presents a self-limitation of the study. However, the intensive reports of silicosis cases associated with denim sandblasting have almost subsided owing to the implemented protective measures and awareness-raising initiatives as well as banning of the procedure as a consequence governmental policies. We are in the opinion that all data, including those derived from our study, is valuable, and will provide further insight to the disease, which will probably have a historical significance over time as in the smallpox disease.

CONCLUSION

Silicosis is among the most fatal occupational lung diseases. Cases associated with denim sandblasting reported predominantly from Turkey have been a major topic in the global healthcare agenda. The nature of the disease and its causative factors were identified particularly by the studies in Turkey, and the required public awareness was raised with the efforts of health societies. On the healthcare policies level, uncontrolled small-sized businesses presenting risk were shut down entirely and the large-scale businesses were forced to adapt their environments to ascertain proper lung and overall body hygiene by implementation of official sanctions. Individuals employed in this business during the unfortunate decade when both the insight and awareness were inadequate have already been exposed to the disease. Younger individuals who started working before complete maturation of the lungs has taken place, those with longer working times (due to the dose-response relationship of silica), and those who work in smaller and confined spaces (due to the effect of environmental residual free silica concentration on the systemic inflammatory response) have been found to be more predisposed to the disease. Restrictive pattern and its indicators, i.e. FVC, %FVC and total losed FVC, may be valuable in monitoring the overall course of the disease, and N/L measurements may be valuable in monitoring the systemic effects.

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