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IMPACT OF DUST EXPOSURE AMONG STONE QUARRY WORKERS ON VENTILATORY FUNCTIONS AND SERUM LEVEL OF TUMOUR NECROSIS FACTOR- ALPHA (TNF-α)

By

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Abstract

Introduction: The health impacts of working in stone quarrying industry have been well documented. Inhalable dust is produced when the stone is cut and by the breaking of the stones on the quarry floor during the transit of the vehicles. A particular concern in some quarries is the inhalation of dust containing silica which can lead to silicosis. Workers exposed to high intensity of dust would have increased Tumour Necrosis Factor-Alpha (TNF-α) in serum which is a strong indicator in predicting the prognosis of pneumoconiosis. **Aim of work:** To find out the relation between serum levels of TNF-α and some spirometric parameters in workers exposed to stone dust during quarrying. **Materials and Methods:** Fifty five workers who were exposed to stone dust in quarrying industry participated in the study. A control group of 55 individuals were randomly selected to be matched with the exposed group as regards age, gender, and special habits of medical importance and not exposed to dust. Full medical history and clinical examination were carried out to all participants. Ventilatory function tests (FVC%, FEV1%, FEV1/FVC%, PEF%, FEF25%, FEF50% and FEF75%) and serum level of TNF-α were measured for both groups. **Results:** There were mild to moderate restrictive ventilatory impairment and mild obstructive impairment among the exposed group (statistically highly significant ($p<0.001$) when compared to the control . Serum levels of TNF-α were significantly higher among the exposed than the control group. Duration of exposure to dust negatively correlated with spirometric parameters and positively correlated with the serum level of TNF-α among the exposed group. Also

the latter negatively correlated with spirometric parameters. Conclusion: Serum TNF-α can be used as a biomarker for detection and follow up of pneumoconiosis in workers exposed to stone dust in quarrying industry.

Key words: Quarrying, Stone dust, Pneumoconiosis, Tumour Necrosis Factor-Alpha (TNF-α) and Spirometry.

Introduction

The health impacts of working in stone quarrying industry have been well documented. Numerous epidemiological studies have supported the association between respiratory impairment and occupational exposure to dust (Jaber et al., 2015). Inhalable dust is produced when the stone is cut and by the breaking of the stones on the quarry floor during the transit of the vehicles (Ulm et al., 2004).

A particular concern in some quarries is the inhalation of dust containing silica which can lead to silicosis, an irreversible lung disease resulting in inflammation of the lungs and breathing difficulties which progresses even when exposure stops (Isara et al., 2016).

The pulmonary defence mechanisms for inhaled dust particles consist of three interrelated systems that work together: mechanical air filtration, liquid mucus which serves as a physical and chemical defence that has bactericidal and detoxifying properties, and specific defence mechanisms that are divided into two systems: the primary humoral immunity (antibody production) and cellular immunity (T-lymphocytes). Macrophages are a cellular defence system that cleans all the deposited small particles by phagocytosis mechanism (Tolinggi et al., 2014).

Immune cells interact with antigens which lead to the release of chemical substances called cytokines that affect other cells and coordinate appropriate immune responses. Cytokines include interleukins, interferons, growth factors, monokines, and lymphokines (Prakova et al., 2015). Measurement of soluble cytokines in vivo and in vitro is becoming increasingly important in studying and controlling pulmonary diseases (Chowdhury et al., 2009).

Workers exposed to high intensity of dust would have increased tumour necrosis factor - alpha (TNF-α) in serum (Cowie et al., 2005). TNF-α is a strong indicator in predicting the prognosis of pneumoconiosis (Zhang and Chen,

2002). In a study done by Lee et al., 2010, they stated that the initial concentrations of tumor necrosis factor-alpha (TNF-α) were related to the progression of coal workers pneumoconiosis (CWP). TNF-α in pneumoconiosis induced by coal dust was reported to be a powerful tool to estimate individual prognosis of pneumoconiotic disease, even after the end of occupational exposure (Lee et al., 2010).

Aim of work

To find out the relation between serum levels of TNF-α and some spirometric parameters in workers exposed to stone dust during.

Materials and Methods

Study design: comparative cross sectional study.

Place and duration of study: the study was carried out in a stone quarry in Sokhna during the period from November 2015 to April 2016.

Study sample: All workers who met the inclusion criteria and agreed to participate in the study were 55 males, their ages ranged between 48-33 years. Inclusion criteria for exposed group were exposure to stone dust during the quarrying and stone cutting process. The duration of exposure was not specified. Exclusion criteria included the presence of any autoimmune diseases, receiving immunosuppressive therapy and exposure of other substances (e.g. chemicals, solvents, metals) from other dusty jobs outside the factory if any.

A control group of 55 individuals were randomly selected as to be matched with the exposed group as regards age, gender, and special habits of medical importance. They were patients coming to outpatient clinic at Kasr Alainy Hospital. They all had no history to exposure to any type of dust and had no respiratory or autoimmune diseases.

Study methods:

1. Pre-designed Questionnaire:

Full history was taken by the authors according to a pre-designed questionnaire, including personal, occupational, present, past and family histories.

2. Clinical Examination

Full clinical examination (general examination including vital signs and local examination of the chest) was carried out to the studied groups. The weight and height were taken for the

study groups using a medical weighing scale with a mechanical height rod.

3. Laboratory Investigation

A blood sample of 3 ml was drawn through venipuncture of the arm using sterile plastic syringe. Blood was centrifuged for separation of serum to determine the level of TNF-α using Human TNF-alpha ELISA kit provided by KOMABIOTECH (www.komabiotech.com) for all individuals (the exposed and control groups). This kit is used for quantitative measurement of human TNF-α levels from samples including serum, plasma, culture medium or other biological fluids in a sandwich ELISA format.

4. Pulmonary function tests

Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), FEV1/FVC, peak expiratory flow rate (PEF), forced expiratory flow rates (FEF25%, FEF50% and FEF75%) were measured for the studied groups using a portable spirometry (Ganshorn Medizin Electroinc).

Consent

An informed verbal consent was taken from subjects who agreed to participate in the study before the start of work with assurance of confidentiality and anonymity of data.

Ethical approval

Approval of the administrative authority of the company was obtained. The study protocol was approved by the Ethical Committee of the Department of Occupational and Environmental Medicine, Faculty of Medicine, Cairo University.

Data management

Data were analyzed using SPSS 16. The mean values, standard deviation (SD) were estimated for quantitative variables. Comparisons between the exposed and control groups were done using Chi Square test for qualitative variables, and independent samples t- test for normally distributed quantitative variables. Meanwhile, the nonparametric Mann-Whitney was used for not normally distributed quantitative variables. Correlations were done to detect the liner relations between quantitative variables. p values less than 0.05 ($p<0.05$) were considered statistically significant, and p values less than 0.001($P<0.001$) were considered highly statistically significant.

Results

Table (1): Some demographic characteristics of the studied groups.

Items	Exposed group Mean± SD		Control group Mean± SD		t	p value
Age (years)	40.32± 7.66		39.23±9.34		0.56	>0.05
Weight (Kg)	85.05±7.06		83.43±6.70		0.47	>0.05
Height (m)	1.71±4.96		1.73±5.11		1.72	>0.05
Smoking habit	**No**	**%**	**No**	**%**	χ^2	>0.05
Smokers	10	18.1%	7	12.7%	0.62	
Non-smokers	45	81.8%	48	87.2%		

Table (1) showed that there was no statistical significant difference (p>0.05) between the exposed and the control groups as regards age, weight, height, and smoking habit. Independent Student's t-test was used to compare their ages, weight and height, while Chi-square was used to compare their smoking habit.

Table (2): Comparison between the studied groups as regards some spirometric parameters.

Parameters	Exposed group Mean± SD	Control group Mean± SD	z	p value
FVC% of predicted	69.41± 6.37	88.76± 6.19	9.01	**<0.001****
FEV1% of predicted	73.27± 10.50	82.56 ±18.55	4.10	**<0.001****
FEV1/FVC	76.94± 6.41	82.87± 11.70	2.72	**<0.001****
PEF% of predicted	62.74± 18.12	82.09± 6.40	6.31	**<0.001****
FEF25% of predicted	73.52 ±16.94	92.92 ±19.72	3.99	**<0.001****
FEF50% of predicted	76.52± 19.44	86.20 ±8.76	3.14	**<0.001****
FEF75% of predicted	66.34± 19.77	82.16 ±7.24	5.65	**<0.001****

z: Mann-Whitney test **: Highly statistically significant

Table (2) showed that there was mild to moderate restrictive ventilatory impairment and mild obstructive impairment among the exposed group which was statistically highly significant compared to the control group (p<0.001). There was also a mild to moderate air flow limitation as regards the peak expiratory flow rate (PEF%) and forced expiratory flow rate75% (FEF75%). Moreover, there was mild airflow limitation as regards the forced expiratory flow25% (FEF25%) and forced expiratory flow50% (FEF50%) which was statistical highly significant compared to the control group (p<0.001).

Table (3): Comparison of the serum levels of Tumour Necrosis Factor-Alpha (TNF-α) among the studied groups.

	Exposed group	Control group	z	p value
TNF-α (pg/ml)	3.54 ±0.82	2.18± 0.38	9.02	**<0.001****

z: Mann-Whitney test **: Highly statistically significant

Table (3) showed that there was a highly statistically significant difference (p<0.001) between the exposed and the control groups as regards the serum level of TNFα.

Table (4): Correlation between the duration of exposure to dust among stone quarry workers and some measureable parameters.

Parameters	r	p value
FVC% of predicted	-0.71	**<0.001****
FEV1% of predicted	-0.39	**<0.05***
FEV1/FVC%	-0.38	**<0.05***
PEF% of predicted	-0.33	**<0.05***
FEF25% of predicted	-0.43	**<0.05***
FEF50% of predicted	-0.45	**<0.05***
FEF75% of predicted	-0.35	**<0.05***
TNF-α (pg/ml)	0.82	**<0.001****

*: Statistically significant **: Highly statistically significant

Table (4) showed that there was a negative correlation between the duration of exposure to dust among stone quarry workers and FVC% which was statistically highly significant (P<0.001). Also, there were negative statistically significant correlations (<0.05) between the duration of exposure and FEV1%, FEV1/FVC%, PEF%, FEF25%, FEF50% and FEF75%. Meanwhile, there was a positive statistically highly significant correlation (P<0.001) between duration of exposure and serum level of TNF-α.

Table (5): Correlation between the serum level of TNF-α (pg/ml) and some spirometric parameters.

Parameters	r	p value
FVC% of predicted	-0.62	**<0.001****
FEV1% of predicted	-0.14	>0.05
FEV1/FVC%	-0.13	>0.05
PEF% of predicted	-0.38	**<0.001****
FEF25% of predicted	-0.75	>0.05
FEF50% of predicted	-0.41	>0.05
FEF75% of predicted	-0.30	**<0.001****

**: Highly statistically significant

Table (5) showed that there were statistically highly significant negative correlations between the serum level of TNF-α and FVC%, PEF% and FEF75%. Meanwhile, the negative correlations between the serum level of TNF-α and FEV1, FEV1/FVC%, FEF25% and FEF50% were statistically insignificant (p>0.05).

Discussion

Quarry industries result in inhalation of air borne particulates that endanger the health and safety of the workers (Aigbokhaode et al., 2011). Pro-inflammatory cytokines (TNF- α) initiate systemic inflammation that may worsen disease due to induction of inflammation or tissue destruction (Strober and Fuss, 2011).

The current study was performed to explore an association between serum levels of TNF-α and some spirometric parameters among workers exposed to stone dust during quarrying.

In the current study, the exposed workers and control groups were matched as regards age, weight, height and smoking habit. There were no statistically significant differences between both groups as regards the previously mentioned items (Table 1).

As regards ventilatory pulmonary function tests, the exposed workers showed mild to moderate restrictive ventilatory impairment and mild obstructive impairment among the exposed workers (Table 2). This was concomitant with Jaber et al., 2015 who conducted their study on stone-cutting workers in the West Bank and Gaza, Palestine. They found that 20.1% of the workers showed restrictive impairment and 1.5% showed obstructive one.

On comparing the results of spirometric parameters between the exposed and the control, they were highly statistically significantly ($p<0.001$) lower among the exposed compared to the control (Table 2). This is in accordance with Isara et al., 2016 who performed ventilatory pulmonary function tests to quarry workers in Edo State, Nigeria. The FEV1 and FVC of the exposed Nigerian workers were significantly lower than that of the control group ($p<0.05$).

Tumor necrosis factor- α (TNF-α) was found to be statistically significantly higher among the exposed compared to the control group ($p<0.001$) (Table 3). This is similar to the results obtained by Prakova et al., 2015 who has conducted their study on workers exposed to inorganic dust. Those workers were further divided into group A exposed to dust from moulding mass for metal castings composed of quartz sand with added coal ash and bentonite,

and group B exposed to dust mixture of iron and artificial abrasives. They found statistically significantly higher differences in group A as compared to both group B ($p<0.02$) and the control group ($p<0.001$).

Jaber et al., 2015 found that stone-cutting workers with longer duration of exposure to dust at work had higher risk for having impaired lung functions. This was comparable with what has been found in the current study as regards the correlations between duration of exposure to dust at work and lung function parameters. Negative correlations with statistically significant differences were recorded (Table 4).

The current study also showed a highly statistically significant positive correlation between the serum levels of TNF-α, and the duration of exposure to dust at work among the exposed group (Table 4). Similar results was detected by Codorean et al., 2011, who found significantly higher levels of TNF-α among workers exposed to coal dust compared to the control group, and increased levels of TNF-α proportional to the duration of exposure.

Meanwhile, Lee et al., 2010 declared that there was no observed difference between serum levels of TNF-α and duration of exposure. They investigated the relevance of serum cytokines as biomarkers in coal worker's pneumoconiosis. They found that TNF-α level in serum was significantly higher among the subjects with low FEV1% (<80%) than in those with normal FEV1%. They concluded that serum levels of TNF-α were associated with the progression of coal worker's pneumoconiosis. This was consistent with the findings in this study as regards the correlations between serum level of TNF-α and spirometric parameters. There were highly statistically significant negative correlations between serum level of TNF-α and FVC%, PEF% and FEF75%., while the negative correlations between the serum level of TNF-α and FEV1, FEV1/FVC%, FEF25% and FEF50% were statistically non-significant ($p>0.05$) as shown in (Table 5).

Conclusion

Spirometric parameters in workers exposed to stone dust during quarrying were significantly lower

when compared with their matched controls. Serum levels of TNF-α were significantly higher among workers exposed to stone dust compared to control group. Duration of exposure positively correlated with serum levels of TNF-α and negatively correlated with lung function parameters. Correlations between TNF-α and FVC%, PEF% and FEF75% were negative (highly statistically significant). Serum TNF-α can be used as a biomarker for detection and follow up of pneumoconiosis in workers exposed to stone dust in quarrying.

Conflict of interests

Authors have declared that no conflict of interest exists.

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