Clinical Evidence: The Prolonged Dust Exposure The Disorder In Serum Oxidant - Antioxidant Balance

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Abstract

Dust can be considered as an important factor in environmental pollution which has a direct effect on human health. In this study ,we attempted to evaluate serum oxidant -antioxidant balance in workers dust exposed continuously and also the effect of iron and silicon content in exposed dust on the mentioned balance .The study included three groups: A group included 20 workers of building block factories, B group included 20 workers in general company of grains production and C group included 15 healthy subjects which represented control group. Iron and silicon contents in dust samples of two studied regions were measured. Higher levels of iron and silicon were found in A group region compared to B group region. Our results illustrated a significant elevation in serum (MDA) level(the index of lipid peroxidation) for A group compared to Band C groups. Also, a significant decrease in serum albumin level was found in A group compared to C group as well as serum ceruloplasmin level in A group was found to be significantly elevated compared to B and C groups. A negative correlation was found between serum MDA and serum albumin levels in A and B groups. Also ,positive correlations were found between serum MDA and each of serum ceruloplasmin and daily dust exposure time in A and B groups. These results provide a new conclusion that the iron and silicon content in prolonged exposed dust lead to disorder in serum oxidant - antioxidant balance.

Introduction

Dust particles contain different elements such as silica, alumina, iron, copper cobalt ,etc. Many of these components have an essential role in generation of oxygen free radicals. Silica, iron and copper can be considered the more effective metals than the others for their contribution in several reactions in which free radicals are produced such as Fenton and Habber -Weis reaction (1-3)

It is well - known that the high amounts of free radicals in human body play a pathologic role where they-ll-ave7 been well recognized as important intermediates in biological reactions and as a primary cause of cell injury and tissue damage in a variety of pathophysiologic processes(4-7).

In the late 1980s and last decade, a considerable studies evidence has also implicated free radicals in pulmonary diseases caused by air pollutants, occupational exposure and tobacco smoke (8-11).

Normally, the increase in free radicals production lead to the enhancement of peroxidation of cell membrane lipids. As a result, antioxidants such as ceruloplasmin albumin,superoxide dismutase (SOD), glutathion peroxidase uric, acid,vitamin E, and vitamin C perform their work to scavenge free radicals (12)Consequently, these antioxidants will increase or decrease in the opposite state of the normal cases (13).

In general, several studies illustrated that the disorder in peroxidation antioxidants balance for a long time leads to several acute and chronic diseases such as cancer, myocardial infarction, diabetes mellitus, respiratory diseases, hypertension as well as atherosclerosis (14-17).

From such a serious view it is an important task of this research to study the effect of prolonged exposure to dust on peroxidation-antioxidant balance in Iraqi workers.

Design of study:

The study was conducted in Thi-Qar governorate during the period from July 1,2002 to November 1, 2002. Fifty five (55)non smoker subjects were included in the study. They have been classified into three groups as the following:

A group: included (20) twenty workers in factories of building block

production in Thi-Qar (region A).

B group: included (20) twenty workers in the general company for grains production in Thi-Qar (region B).

C group: included (IS)healthy subjects that represent control group for comparison with A and B groups

It is notable that many clinical and characteristics data (age, sex, daily dust exposure time (DDET) chest x-ray Hb, erythrocytes sedimentation rate(ESR) and white blood cells (WBC) for all studies groups were shown in (table 1).

Collection of Blood Samples

(8ml) of blood have been withdrawn from the study subjects by venipuncture at 9 a.m. then (2 ml) of the blood were transferred into anticoagulant tube to use it in Hb WBC and ESR measurements. The remainder were placed in a disposable tube and centrifuged (750xg, 10 min.) within 15 min. after collection , the produced serum stored at -20 c unless used in work immediately.

Methods

Dust Measurements

Silicon and iron levels in dust samples, collected from different positions of study regions, were measured by use of atomic absorption spectrophotometer (type Shimadzu (Japan)). The dust samples were dissolved in $(HClO_4 + HNO_3)$ with adding (HF) Hydrofiuoric acid.

Lipid Peroxidation Measurement

Lipid peroxidation status were evaluated by determination of serum malondialdehyde level which is considered as a lipid peroxidation marker. Serum MDA level were determined according to the method of Fong et al.1973 (18).

Where MDA reacts with thiobarbituric acid (TBA) to produce a colored complex MDA(TBA)Z which has the best absorbancy at 532 nm.

Antioxidants Measurements

Serum albumin levels were measured by a dye-binding procedure

which is based on a shift in the absorption maximum of the dye when bound to albumin (albumin kit supplied by Randox laboratories, England) (19). Ceruloplasmin levels were determined by a colorimetric method which depends on the oxidize activity of cernloplasmin . The substrate (paraphenylenediamine) is converted to the oxidized colored form (20), which has the best absorbancy at 525 nm. It is notable that the corrected absorbance is directly related to the concentration of ceruloplasmin (21).

Statistical Analysis

Data shown were the means and standard deviations. Students -t-test analysis also made to compare among the studied groups and each others. Value of equal or less than $p \leq 0.05$ was considered significant. At last associations of parameters with each others were evaluated as correlation coefficient(r) values.

Results

Table (2) shows significant differences in iron levels in dust between A and B group regions, while no significant differences in silicon levels between A and B group regions were found.

A significant increase can be observed in serum (MDA) levels in A and B groups , compared to control group as show in table (3). However, the same table demonstrates a significant increase in serum MDA levels-- in A group compared to B group. Figure (1) shows serum MDA levels in all studied groups. As for table (4), it illustrates significant differences in serum albumin levels among all studied groups. Also, this relation was illustrated in figure (2). Table (5) demonstrates a significant elevation in serum ceruloplasmin levels in A group compared to B and control groups. Also serum ceruloplasmin level in B group elevates significantly compared to control group, this relation was shown in figure (3).Figure (4) shows a negative correlation relationship between serum albumin level and MDA level in A and B groups. A positive correlation relation can be observed between serum ceruloplasmin level and serum MDA level as shown in figure (5).A positive correlation relationship was found between serum MDA level and daily dust exposure time due to their
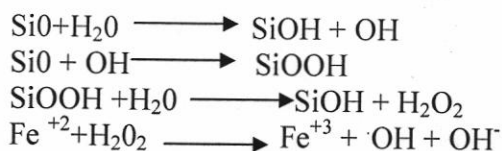
occupation as shown in figure (6) .

Discussion

Our results provide evidence that lipid peroxidation process is enhanced by prolonged dust exposure. As malondialdehyde (MDA) "an end product for lipid peroxidation" can be considered as a biomarker for free radicals generation (22). Indeed ,the elevation in serum MDA in A and B groups, which was reported in our data, can be explain according to two ways: the first, when dust particles enter the respiratory tract, phagocytes are stimulated by immune complexes in the whole tract; as a result, superoxide radical O-2 are produced according to mechanism of Laurence and Boxer [23]:

$$NADPH + 2O_2 \longrightarrow NAD^+P + H^+ + 2O_2^-$$

This produced radical, in turn, undergoes further reactions to form another toxic species such as H_2O_2, OH and organic oxygen radicals which perform destruction normal cells in site of infection with dust particles (24). Consequently, membrane lipid peroxidation happens rapidly, which leads, normally, to an elevation in serum MDA levels.
The second way for explanation of elevation of serum MDA levels in our data: is due to the dust content of silicon and iron, our results illustrated high levels of silicon and iron in A group region compared to B group region. These levels of iron and silicon were compatible with serum MDA levels in A and B groups . In vitro study have reported that generation of free radicals increase in presence of silicon and iron in aquase media by the following supposed mechanism (25) :

$$SiO + H_2O \longrightarrow SiOH + OH$$
$$SiO + OH \longrightarrow SiOOH$$
$$SiOOH + H_2O \longrightarrow SiOH + H_2O_2$$
$$Fe^{+2} + H_2O_2 \longrightarrow Fe^{+3} + \cdot OH + OH^-$$

Evidently ,our in vivo data provide additional support for the above mechanisms. Indeed, this means that chronic dust, contains high levels of

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silicon and iron, exposure leads to oxidative stress.

On the other hand, in the present study, the level of albumin observed provided biochemical link to the increase oxidative stress. We could interpret, in introduction, the decrease in antioxidants as a compensatory mechanism in response to increased free radicals generation. This, simply, was shown in correlation relation between MDA and albumin (Fig. 4). Albumin is one of primary antioxidants, which forbids production of new free radicals. It can be considered as physiological ligand for copper ions (II) (26). The latter enter, if they free, Fenton and Habber Weiss reactions, which produce (OH) hydroxyl radical (26). However, albumin does not prevent formation of hydroxyl radicals by the mentioned reactions (27). Therefore, OH radicals immediately attack albumin and lead to destruction in the protein molecules (28). As a result, serum albumin level decreases.

As for ceruloplasmin, it has enzymatic activity, therefore, the elevation in its levels in A and B groups compared to control can be considered as a normal result to the increase in free radical generation and lipid peroxidation during chronic dust exposure. However, ceruloplasmin performs conversion ferrous ions (II) to ferric ions (III) ,therefore, it can be considered as ferroxidase. Consequently, transferrin is capable of carrying ferric ions and prevents Fenton free radical generation reaction. Additionally, ceruloplasmin is an affective vehicle for copper ions (29), therefore, it prevents copper catalyzed Habber Weiss reaction, which produces new free radicals. All these activities of ceruloplasmin enhance hepatic cells to secrete it rapidly during oxidative stress [2] : The correlation relation between MDA and ceruloplasmin (Fig. S) supports the above explanation.

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Table (1)The Clinical And Characteristics Data For All Studied Groups

Groups	n	sex	Age (y)	DDET (hr)	x-ray	Hb (g/100 mL)	WBC (M/mm3)	ESR (mm/hr)
A	20	M	33.4±3.1	7.3±3.2	+	12±2.2	9300±2500*	21±9**
B	20	M	30.1±4.4	6.1±2.7	+	12±2.7	7900±2200	15±3*
Control	15	M	.30.3±1.1	-	-	12±1.3	6.100±1100	7±2

p*<0.05 compared with control group (C)
p**<0.05 compared with control and *

Table (2) Silicon And Iron Levels In Dust Sample In Two Studied Regions

regions	Silicon (ppm)	Iron (ppm)
A	0.021	0.032*
B	0.019	0.015

Table (3) Serum MDA Levels In All Studied Groups

Groups	n	MDA (nMol/l)
A	20	78.3±7.6**
B	20	40.1±5.3*
C	15	12.7±2.2

Table (4) Serum Albumin Levels In All Studied Groups

Groups	n	Alb(g/l)
A	20	36.4±0.5*
B	20	39.1±0.2
C	15	40.4±0.3

Table (5) Serum Ceruloplasmin Concentrations In All Studied Groups

Groups	n	Cp(mg/l)
A	20	301.2±13.4**
B	20	253.4±7.5*
C	15	198.7±3.4
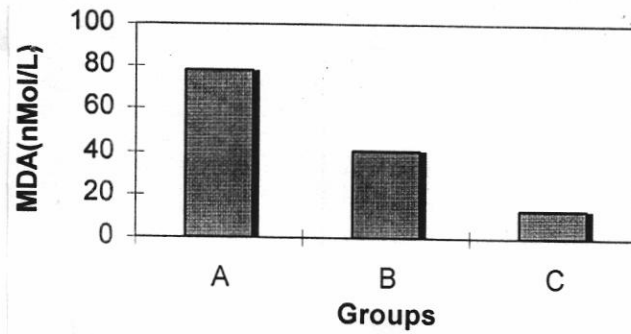
Fig.(1)Serum MDA Levels In All Studied Groups
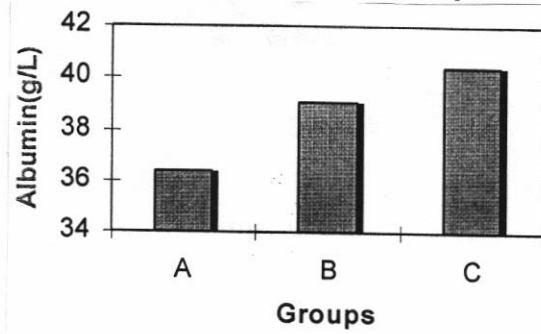
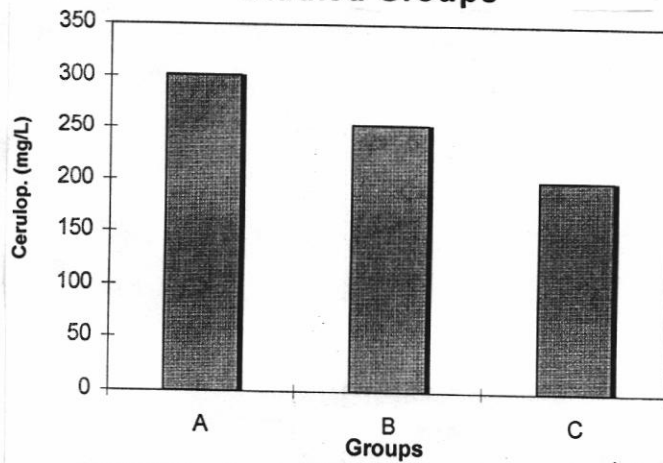Fig.(2) Serum Albumin Levels In All Studied Groups
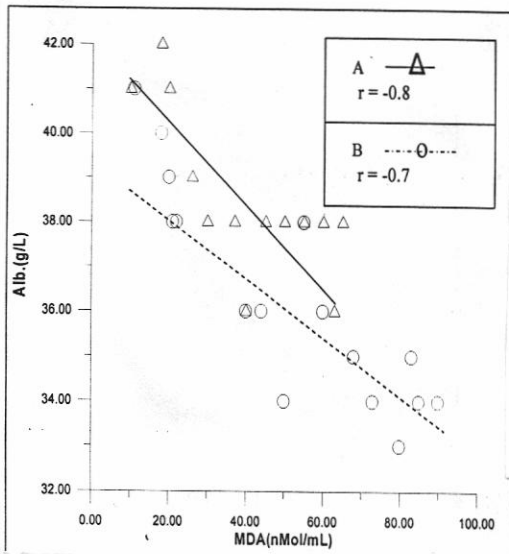

Fig.(3) Serum Ceruloplasmin Levels In All Studied Groups

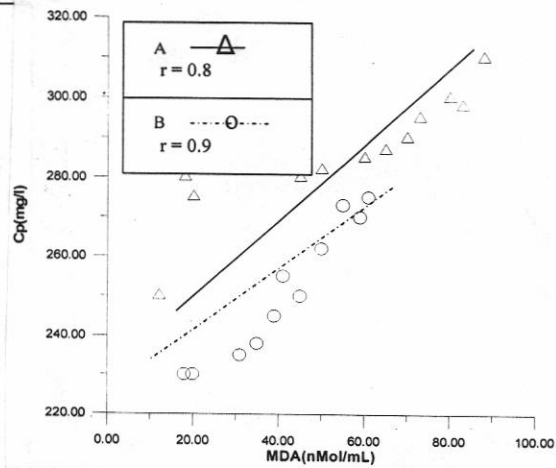Fig.(4) Relation Between Serum MDA and Albumin Levels in A and B Groups

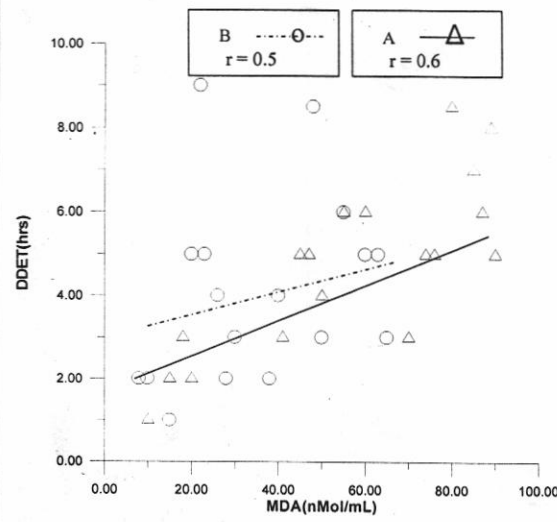Fig.(5) Relation Between Serum MDA and Ceruloplasmin Levels in A and B Groups

Fig.(6) Relation Between Serum MDA Levels and (DDET) in A and B Groups

دلائل سريرية تثبت أن التعرض المستمر للغبار يؤدي الى خلل في توازن أكسدة – مضادات أكسدة في مصل الدم

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الخلاصة

يعتبر الغبار أحد العناصر المهمة الملوثة للبيئة والتي لها تأثير على صحة الانسان ، حاولنا في هذه الدراسة تقييم توازن أكسدة – مضادات أكسدة في مصل الدم للعاملين المتعرضين للغبار وبصورة مستمرة وتأثير محتوى الغبار من عنصري الحديد والسيلكون على ذلك ، شملت الدراسة ثلاث مجاميع : المجموعة (A) ضمت (20) عاملا في معامل طابوق البناء ، والمجموعة (B) ضمت (20) عاملا أيضا في الشركة العامة لانتاج وتسويق الحبوب ، والمجموعة (C) التي ضمت (15) شخصا من الأصحاء غير المتعرضين للغبار (مجموعة السيطرة) . تم قياس مستوى كل من الحديد السليكون في الغبار في منطقتي الدراسة حيث وجدت زيادة معنوية في مستوى الحديد والسليكون في منطقة الدراسة A مقارنة مع مستواهما في B . أثبتت نتائجنا وجود زيادة معنوية في مستوى المالون داي الديهايد مع (MDA) بكل من B،A وكذلك وجود انخفاض معنوي في مستوى الألبومين في A مقارنة مع C،B . كذلك وجدت علاقة ترابطية سالبة بين MDA والألبومين وعلاقة ترابطية موجبة بين MDA وكل من السيروبلازمين ومدة التعرض للغبار في المجموعتين A ،B. في ضوء تلك النتائج تم الاستنتاج بأن التعرض المستمر للغبار يؤدي الى خلل في توازن أكسدة – مضادات أكسدة ، وتعتمد درجة الخلل على محتوى الغبار من عنصري الحديد والسليكون .