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Evaluation of Blood Components, Oxidative Stress, and Biochemical Markers in Badoush Cement Workers with Asthma

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Abstract

Asthma has recently become more prevalent among cement workers, primarily due to their exposure to air pollutants, especially in factories where protective measures are insufficient. Asthma is a chronic chest disease that affects the lungs, by causing the airways which carry air to and from the lungs' tighten, creating breathing difficulties. This study aimed to assess the impact of air pollutants from cement plants on workers with asthma in the Badoush area. Several blood components were assessed, including hemoglobin concentration (Hb), packed cell volume (PCV%), platelet count (PLTs), white blood cell count (WBCs), and red blood cell count (RBCs). Additionally, kidney and liver functions, oxidative status, and antioxidant levels were evaluated. The study was conducted on workers employed at the cement production plants with asthma in the Badoush area, during the period from August to December 2023. It included 40 asthmatic workers with disease durations ranging from 1 to 10 years, along with a control group of 40 with the same ages ranging from 35-55 years. Results indicated that there was a rise in oxidative stress state in cement workers with asthma, and a decrease in the number of RBCs, WBCs, Hb concentration, and PCV% compared to the control group. The results also showed elevated levels of urea and creatinine, along with increased activities of the enzymes CA, AST, ALT, and ALP in cement workers with asthma. Additionally, an enhanced oxidative stress was observed in these workers, characterized by decreased antioxidant levels and a rise in oxidant levels in comparison to the control group. Overall, there is a clear effect of cement pollutants on cement workers with asthma, which leads to an increase the anaemia and affects the functions of the kidneys and liver with an increase in oxidative stress among them, which requires sick workers to take more precautions than other workers who do not suffer from asthma.

Keywords: Asthma, Cement Factory, Air Pollution, Blood, Oxidative stress.

تقييم مكونات الدم والاجهاد التأكسدي والعلامات كيموحيوية لدى عمال سمنت بادوش المصابين بالربو

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الخلاصة

ازداد انتشار الربو مؤخرًا بين عمال الأسمنت، ويعود ذلك أساسًا إلى تعرضهم لملوثات الهواء، وخاصةً في المصانع التي لا تتوفر فيها إجراءات وقائية كافية. الربو مرض صدري مزمن يصيب الرئتين، إذ يُسبب ضيقًا في الممرات الهوائية التي تحمل الهواء من وإلى الرئتين، مما يُسبب صعوبات في التنفس. هدفت هذه الدراسة إلى تقييم تأثير ملوثات الهواء من مصانع الأسمنت على العمال المصابين بالربو في منطقة بادوش. تم تقييم العديد من مكونات الدم، بما في ذلك تركيز الهيموكلوبين (Hb)، وحجم خلايا الدم المرصوصة (PCV%)، وعدد الصفائح الدموية (PLTs)، وعدد خلايا الدم البيض (WBCs)، وعدد خلايا الدم الحمر (RBCs). بالإضافة إلى ذلك، تم تقييم وظائف الكلى والكبد، والحالة التأكسدية، ومستويات مضادات الأكسدة. أُجريت الدراسة على العمال المصابين بالربو في مصانع إنتاج الأسمنت في منطقة بادوش، خلال الفترة من اب الى كانون الاول 2023. شملت الدراسة 40 عاملاً مصاباً بالربو، تتراوح مدة مرضهم بين سنة الى عشرة سنوات، بالإضافة إلى مجموعة سيطرة تضم 40 عاملاً، تتراوح أعمارهم بين 35 و55 عاماً. أشارت النتائج إلى ارتفاع في حالة الإجهاد التأكسدي لدى عمال الأسمنت المصابين بالربو، وانخفاض في عدد كريات الدم الحمر، وكريات الدم البيض، وتركيز الهيموكلوبين، ونسبة حجم كريات الدم المرصوصة مقارنةً بالمجموعة الضابطة. كما أظهرت النتائج ارتفاعاً في مستويات اليوريا والكرياتينين، إلى جانب زيادة في نشاط إنزيمات CA وAST وALT وALP لدى عمال الأسمنت المصابين بالربو. بالإضافة إلى ذلك، لوحظ ارتفاعٌ في الإجهاد التأكسدي لدى هؤلاء العمال، والذي اتسم بانخفاض مستويات مضادات الأكسدة وارتفاع مستويات المؤكسدات مقارنةً بالمجموعة السيطرة. وبشكلٍ عام، هناك تأثيرٌ واضحٌ لملوثات الأسمنت على عمال الأسمنت المصابين بالربو، مما يؤدي إلى زيادة فقر الدم ويؤثر على وظائف الكلى والكبد مع زيادة الإجهاد التأكسدي لديهم، مما يتطلب من العمال المرضى اتخاذ احتياطاتٍ أكثر من غيرهم من العمال غير المصابين بالربو.

1. Introduction

Asthma is a complex disorder shaped by genetic predisposition and environmental factors, particularly during early life, within a multifaceted exposure framework [1-3]. The respiratory system is impacted by outdoor pollution from sources such as heating, industry, traffic, and energy generation, either directly or indirectly through their function as precursors of other polluting particles [4,5].

The cement industry is among the sectors that contribute significantly air pollution and adverse human health effects[6]. Air pollution, diesel exhaust particles (DEP), traffic-related air pollutants (TRAPs), ozone (O_3), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) can increase mucosal membrane permeability, facilitate allergen penetration, and enhance immune system cell contact[7,8]. The human hemopoietic system is the ideal indication in toxicological studies because it is known to be extremely sensitive to environmental impacts and destruction of cells with consequent heavy metabolic demands [9,10] .

Among the studies in this area, the research by Aslam *et al*., (2023) investigated the relationship between asthma, socioeconomic status, demographics, and air pollution[11]. Questionnaires were administered to four age groups—15–25, 25–45, 45–60, and over 60, at public and private hospitals in Lahore. Concurrently, daily average concentrations of five air pollutants: carbon monoxide (CO), NO_2, SO_2, O_3, and particulate matter ($PM_{2.5}$ and PM_{10}) were recorded from ten permanent air monitoring stations across Lahore city. Throughout the course of the study, there were positive correlations found between the percentage of asthma visits to the outpatient department (OPD) (64%) and the outdoor air quality throughout the winter months. When 1, 29, and 370 asthma patients average daily air pollution levels were correlated, it was discovered that women were more likely than men to have asthma (53%) [11]. As the study of Zhou and his group (2024) showed that Chinese preschoolers' prolonged exposure to PM2.5 was linked to an increased risk of asthma; the children in this survey who lived in suburban or rural areas were significantly more vulnerable to PM2.5 exposure[12] .

Whereas Sepehri *et al* (2024) studied the effect of air pollution, sulfur dioxide and ozone on oxidative stress parameters, liver histopathology, and expression of some cancer-related genes in liver tissues of rats[13].

The aim of this research was to investigate the effects of contaminants emitted by the cement labs in Badoush region (Badoush Cement Expansion Plant, Badoush New Cement Plant) on workers with asthmatic workers. The study focused on evaluating the impact of these pollutants on selected blood components and several biochemical variables in serum, and studying the extent of oxidative stress events due to exposure of workers to these contaminants and compared to the health group.

2. Experimental:

2.1. Materials and Methods

This study was carried out at the Badoush Expansion Factory and Badoush New Factory, both part of the State Company for Northern Cement Industry. Located approximately 25 km north of Mosul city in Hamidat District, the cement production facility was divided into five study sites: the Management Unit, Crusher Unit, Material Mills Unit, Furnace Unit, and Cement Packaging Unit.

Sample collection: During study, blood samples were collected from the beginning of August until the end of December 2023, from male workers working in cement production plants, including workers with asthma (40) who were exposed to air pollutants resulting from the cement industry (Suspended particles, carbon oxides, sulfur oxides, and nitrogen oxides) they were diagnosed by recording their health information as well as by specialist doctors in the health center affiliated with the cement plants (Workers with a history of chronic diseases not related to asthma—such as diabetes or cardiovascular disorders—as well as smokers were excluded), and compared with (40) blood samples from healthy people(as a control group not working in the factory) who were not reported to have respiratory diseases and were of the same age as the workers themselves from the Central Blood Bank and were counted as a control group.

Venous blood samples (5–6 ml) were collected from each participant in both the workers' group and the control group. The blood was divided into two portions according to the type of examination: The first portions 1 ml of blood was placed in plastic tubes containing an anticoagulant type ethylene diamine tetra acetic acid(EDTA), and this part of the blood was used for the purpose of conducting a complete blood count (CBC). The remaining 4–5 ml of blood was placed in Jell tubes with tight, dry covers, free of any anticoagulant. The tubes were left for 20 minutes at room temperature, then the blood was separated using a centrifuge for 15 minutes at a speed of 3000 xg, in order to obtain blood serum. It was drawn using a micropipette, divided into parts and placed in dry, sterile plastic Eppendorf tubes, and the serum was stored in a deep freezer at (-20)°C until all the tests required in the current study were performed.

Biochemical tests

The biochemical tests were included (White blood cells count (WBCs), red blood cells (RBCs) count, concentration of hemoglobin (Hb), packed cell volume (PCV%), platelet count (PLTs) using a Sysmix coulter (Sysmex Corporation/Japanese), Principles of measurement Blood is sampled and diluted, and moves through a tube thin enough that cells pass by one at a time. Cell characteristics are analyzed using either laser-based fluorescence flow cytometry or electrical impedance measurements. The kidney and liver functions (Urea, Creatinine, Albumin, Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), Alkaline phosphatase (ALP) using a FUJI NX500 device (Fujifilm, Japan) were estimated. The Carbonic anhydrase (CA) level was evaluated by using Enzyme – Linked

Immunosorbent Assay (ELISA) from Bioassy Technology Laboratory (BTLAB)/ China (Ref. 123456) according to manufacturer's steps. Also, the assessment of antioxidant status was determined by measuring the concentration of glutathione (GSH) [14], Malondialdehyde (MDA) [15], Peroxynitrate (ONOO-) [16] in the serum of the blood using a spectrophotometer.

2.2. Statistical analysis

The SPSS (Statistical Package for the Social Sciences, version 24) was used to perform the statistical analysis. The data were presented as mean ± standard deviation (mean ±SD). To compare the groups, a Completely Randomised Design (C.R.D.) test was performed, and a p-value of ≤ 0.05 was considered as the significance level.

3. Results and discussion

3.1. The impact of cement pollutants on several blood components:

Table 1 shows the effect of cement pollutants on the blood components of cement factory workers with asthma compared to the control group.

Table 1: Comparison of blood components between cement workers with asthma and the control group.

Blood components	Control group		Group of workers suffering from asthma		p value
	Mean	SD	Mean	SD	
WBC ($\times 10^3$/L)	9.12	0.12	8.58	0.80	0.041*
RBCs($\times 10^6$ /L)	5.11	0.21	3.76	0.15	0.038*
Hb (gm/dL)	15.24	0.12	13.64	0.69	0.027*
PCV %	51.68	3.23	41.28	2.08	0.041*
PLTs($\times 10^3$/L)	189.2	9.14	316.0	12.78	0.001*

* There are significant differences between the two groups at $p \leq 0.05$.

As presented in Table 1, the asthma worker group exhibited a significant decrease ($p \leq 0.05$) in white blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), and packed cell volume (PCV) levels, along with a significant increase in platelet (PLT) levels compared with control group.

The respiratory irritation and worsening of conditions such as asthma in cement workers are attributed to pollutants generated during various stages of cement production, including dust, carbon oxides, sulfur oxides, and nitrogen oxides. These pollutants provoke the airways and make respiratory conditions worse especially asthma, and is associated with an inflammatory mechanism. According to the multipollutant model, NO_2 is negatively related to white blood cell count. This result is in line with earlier studies[17]. Due to human hemoglobin's stronger affinity for carbon monoxide than for oxygen, NO_2 can lead to loss of hemoglobin and reduce the amount of oxygen reaching the tissues[18].

The mouth, nose, skin, and digestive tract are among the entry points for air pollutants into the bloodstream. The premature breakdown of red blood cell membranes is known as hemolysis. The lifespan of RBCs may be shorter due to the alteration of their metabolism. All of these adverse effects can cause anemia, jaundice, and other diseases such as asthma. The absorption of mineral components on particles can lead to hemolysis[19]. This leads to high levels of IL-33 in the plasma of asthmatic patients during hemolysis, and RBCs are one of the major sources of IL-33 in plasma[20]. The decrease in Hb and PCV concentrations was due to a decrease in RBC concentration as a result of inflammation, as inflammatory processes lead to the release of cytokines, which inhibit the formation of RBCs in the bone marrow

[21], since the study's findings concurred with those of the two researchers[22,23]. In addition, asthma patients may suffer from malnutrition, such as a deficiency of iron, vitamin B_{12} (Cobalamin), and folic acid (vitamin B9), as anemia resulting from iron deficiency reduces the blood's ability to carry oxygen, which may lead to symptoms of shortness of breath and poor treatment[24]. While the PLT count in the workers with asthma (316×10^3/L) was significantly higher compared to the controls ($p < 0.05$), the high PLT count and low RBC count were a result of exposure to air pollution compared to the control group. This study also indicated that the increased platelet count was a result of the body's exposure to oxidative stress [25].

3.2. The impact of cement pollutants on liver and kidney functions:

According to the results in Table 2, there were statistically significant increases ($p \leq 0.05$) in CA, AST, ALP, urea and creatinine in the workers with asthma compared to the control group, with a significant decrease in ALT.

Table-2 Comparison of enzyme levels (CA, AST, ALT, ALP), urea and creatinine between cement workers with asthma and the control group.

Blood components	Control group		Group of workers suffering from asthma		p value
	Mean	SD	Mean	SD	
CA (Pg/L)	78.99	2.3	101.25	9.47	0.036
AST (U/L)	23.12	0.99	28.40	2.97	0.040
ALT (U/L)	28.56	1.44	23.80	1.95	0.042
ALP (U/L)	68.35	2.89	90.60	2.014	0.038
Urea (mg/dL)	21.34	1.57	31.42	3.41	0.0001
Creatinine(mg/dL)	0.687	0.064	0.92	0.091	0.027

* There are significant differences between the two groups at $p \leq 0.05$.

The results indicate that serum urea and creatinine levels were elevated in dust-exposed workers, were higher than in the controls ($p < 0.05$), likely reflecting reduced kidney function as a result of pollutant exposure. This may be attributed to a reduced glomerular filtration rate, which impedes the excretion of metabolic waste products [26]. Both diseases (asthma and altered kidney function) often lead to the creation of autoantibodies within the body, which may target self-tissues or organs[27]. Specifically, distinct immune cell populations - including natural killer (NK) cells, T cells, B cells, and monocytes - contribute significantly to the pathogenesis of both diseases [28]. Studies have demonstrated that immune complex deposition can cause glomeruli to become inflamed and damaged, which can result in glomerulonephritis[29].

It also recorded a significant rise of enzyme: CA at a rate of 101.25pg/L and AST (28.40 U/L) and ALP (90.60 U/L), besides of a slight decrease in ALT (23.80 U/L). The elevated CA level is due to its elevation in the cells lining the pulmonary blood vessels, such as the epithelial tissue in the alveoli, due to exposure to various air pollutants. The respiratory system is the only system in the body that is in contact with air in the peripheral environment [30]. In our study, CA III level was significantly higher in the asthma group compared to the control group. The enzyme CA, which is present in red blood cells and the lining of the lungs, helps the lungs expel carbon dioxide. As the condition worsens, gas transfer of carbon dioxide and oxygen generally gets worse. Decreased ventilation may also be the result of increased dead space ventilation or decreased respiratory drive. Hypoxemia and carbon dioxide retention could result from this[31]. Severe asthma is characterized by hypercapnic respiratory collapse. When patients with severe acute and chronic lung disorders, including

asthma, have poor alveolar gas exchange, they may experience hypercapnia, an elevation in the arterial carbon dioxide (CO_2) tension[32].
There was also a significant increase in the activities of AST and ALP enzymes in the blood of individuals exposed to cement dust. Cement dust contains components such as free silica, alumina, and heavy metal oxides. Chronic exposure to these substances can lead to chronic toxic effects on the liver. However, rather than causing elevated ALT levels as is common in acute cases, prolonged exposure may lead to hepatocellular inhibition or chronic damage resulting in decreased activity of liver enzymes, including ALT, Cement workers may suffer from nutritional or micronutrient deficiencies, such as vitamin B6 (pyridoxine), which is essential for ALT activity. A deficiency of this vitamin can lead to decreased ALT activity in the blood[33, 34].

3.3. The impact of cement pollutants on oxidants and antioxidants:

Table 3 lists the results of oxidative stress parameters such as: GSH, MDA, $ONOO^-$, and Albumin in workers with asthma and the control group. Several authors have discovered evidence linking asthma to increased oxidative stress in the airways, as demonstrated by the presence of increased oxidative biomarkers[35].
The results revealed that there was a significant decrease in the levels of GSH and ONOO-, while a significant increase in MDA level in workers with asthma as compared to the control group at $p \leq 0.05$. Moreover, there were no significant differences in the asthma workers than the controls regarding the Albumin level, as presented in Table 3.

Table 3 : Comparison of GSH, MDA, ONOO- and albumin levels between cement workers with asthma and the control group.

Blood components	Control group		Group of workers suffering from asthma		p value
	Mean	SD	Mean	SD	
GSH(µmol/L)	12.12	0.78	5.50	3.46	0.002*
MDA(µmol/L)	3.17	0.12	6.70	0.810	0.013*
ONOO-(µmol/L)	53.27	2.12	105.5	13.01	0.0014*
Albumin(gm/dL)	4.45	0.32	3.90	0.22	0.084

* There are significant differences between the two groups at $p \leq 0.05$.

Endogenous reactive oxygen species are produced upon exposure to a variety of air pollutants and can lead to oxidative damage in the lungs. Detoxification is a key line of defence against hazardous environmental exposures. In the lungs, Glutathione S-Transferases have an important protective antioxidant function that subsequently regains inflammatory responses[36]. Antioxidant enzymes are present in the lungs to handle the continuous exposure to various oxidants. These enzymes include superoxide dismutase and glutathione peroxidase; reduced activity or dysfunction of typical antioxidant enzyme defences can be recognized in asthmatic airways. It was observed that workers with asthma had lower levels of glutathione compared to the control group. This may be due to a defect in the key enzymes involved in glutathione synthesis[37]. Low glutathione levels may impair the ability to remove toxins and reactive oxygen species [38].
While it recorded a noteworthy increase in the level of MDA, at a rate (6.70 µmol/L), ONOO- at a rate (105.5 µmol/L). The reason is thought to be that the imbalance between oxidants and antioxidants in the development of the disease is associated with airway obstruction, while MDA is an index of lipid peroxidation used to assess lipid peroxidation due to increased oxidative stress [39, 40]. Elevated fraction of exhaled nitric oxide (FeNO) levels serve as a biomarker for both airway hyperresponsiveness and eosinophilic

inflammation, demonstrating a significant association with disease severity [41]. As noted, low serum albumin level, even if it is not significantly, at a rate (3.90 gm/dL), may be a clinical sign of malnourishment, leading to respiratory muscle weakness and decreased lung function and increased oxidative stress in cement workers with asthma [42,43].

Conclusion

The study concluded that exposure to cement pollutants has a significant impact on cement workers with asthma, contributing to alterations in blood parameters indicative of anemia and impairing kidney, heart, and liver functions. Additionally, these workers exhibited elevated oxidative stress levels. These findings underscore the need for asthmatic workers to adopt enhanced protective measures compared to non-asthmatic colleagues.

Ethical Clearance

Ethical approval was obtained by the ethical committee at the College of Science/ University of Mosul.

Interest Discrepancies

This work is free from any conflicts of interest.

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