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Corresponding author:

Rahnuma Ahmad
 Department of Physiology, Medical College for Women and Hospital, Dhaka.
 Email: rahnuma.ahmad@gmail.com

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Effects of exposure to cement dust on hemoglobin concentration and total count of RBC in cement factory workers

Rahnuma Ahmad¹, Qazi Shamima Akhter²

1. Department of Physiology, Medical College for Women and Hospital, Dhaka.

2. Department of Physiology, Dhaka Medical College, Dhaka.

Abstract

Background : Cement factory workers are exposed to cement dust during their daily work activities. Chronic exposure to cement dust may have adverse effect on the haemopoietic system and the workers would suffer from anemia that may lead to cardiovascular disease. **Objective**: To assess the effects of exposure to cement dust on hemoglobin concentration and total count of RBC in cement factory workers. **Methods** : This cross sectional study was conducted in the Department of Physiology, Dhaka Medical College, Dhaka from July 2017 to June 2018. After fulfilling the ethical consideration, 46 apparently healthy male cement factory workers, working in a cement factory for 2 years or more, with age ranging from 20 to 50 years were study group and 46 age, BMI and socioeconomic condition matched apparently healthy male subjects from different areas of Dhaka city were control group. Hemoglobin concentration and total count of RBC were estimated using automated haematology analyzer. For statistical analysis, Unpaired Student's 't' test and Pearson's correlation coefficient test were performed. **Results**: In this study, hemoglobin concentration and total count of RBC were significantly ($p < 0.05$) lower in study group than those of control group. Hemoglobin concentration was negatively related with duration of cement dust exposure. **Conclusions**: This study concludes that the cement dust exposure had deleterious effect on hemoglobin concentration and total count of RBC and the duration of exposure to cement dust had an impact on hemoglobin concentration.

Key words: Cement dust, anemia.

Introduction

According to the “Glossary of Atmospheric Chemistry Terms”, dust is defined as small, dry, solid particles projected into air by natural forces, such as wind, volcanic eruption, and by mechanical or processes that include smashing, fragmenting, drilling, dusting, packing. Dust particles are usually in size range from about 1 to 100 μm in diameter, and they settle slowly under the influence of gravity¹.

Cement dust is a grey powder and has a diameter between the range of 0.05 μm and 5.0 μm ². It consists of 60-67% calcium oxide (lime), 17-25% silicon oxide, 3-5% aluminium oxide, with some amount of iron oxide, chromium, lead, potassium, sodium, sulphur, mercury, antimony, cadmium, zinc, manganese and magnesium oxide³.

Inhalation and swallowing are the two important routes by which cement dust chemicals enter the body to produce adverse effects⁴. Exposure to cement dust also occurs through eye and skin contact⁵.

In case of a single or short term exposure to cement dust, there is little to no hazard posed to human health. However, chronic exposure to cement dust can lead to deteriorating effects on skin, eye, respiratory and haematological system. Long term cement dust exposure causes irritation of exposed mucous membrane and leads to chronic respiratory diseases including pneumoconiosis, lung cancer^{6,7,8}.

Cement industry is a rapidly growing sector in the world and also in Bangladesh. World cement production rose from 3.7 billion metric tons in 2012 to 5 billion metric tons in 2016⁹. There is emission of dust and particulate matter at the different steps of cement manufacture¹⁰. An estimated 29,000 deaths are caused by silica, asbestos and coal dust exposure worldwide per year¹¹.

Several studies in different countries like Nigeria, India have suggested that cement dust exposure causes hematological changes that includes anemia. The hemoglobin cut off point for anemia in male is 13 g/dl¹². Anemia can lead to

cardiovascular disease such as cardiac arrhythmia, ischchemic heart disease¹³.

Hematological parameters are sensitive index and may be useful as tools for indirect diagnosis and prognosis to assess the toxicity of cement dust⁵. Previous studies in different countries have shown changes in hemoglobin concentration and total count of RBC of the cement factory workers^{2,5,14}. However, in Bangladesh, data is not adequate on this topic. The present study is designed to evaluate the effects of cement dust on hemoglobin concentration and total count of RBC of cement factory workers.

Method

This cross sectional study was conducted in the Department of Physiology, Dhaka Medical College, Dhaka from July 2017 to June 2018. Forty six apparently healthy male cement factory workers, working in a cement factory in Munshigonj for 2 years or more, with age ranging from 20 to 50 years were study group and forty six age, BMI and socioeconomic condition matched apparently healthy male subjects from different areas of Dhaka city were control group based on the inclusion and exclusion criteria. Subjects with history of respiratory disease, acute infection, cardiac disease, hematological disease, liver disease, renal disease, malignancies, hypertension; history of taking anticoagulant, chemotherapy, iron therapy and recent history of blood transfusion were excluded from the study. The study group was divided into two groups on the basis of duration of cement dust exposure, that is, subjects exposed to cement dust for 2-6 years and subjects exposed for 7-12 years.

After selection of the subjects informed written consent was taken from them. The research work was carried out after obtaining ethical clearance from Ethical Review Committee of Dhaka Medical College, Dhaka. All the information was recorded in a pre-designed data schedule. With aseptic precaution, 2 ml of venous blood were collected from ante-cubital vein and taken in a tube with EDTA anticoagulant for estimation of hemoglobin concentration and total count of RBC. The collected blood sample was analyzed in the

Department of Laboratory Medicine, Dhaka Medical College hospital, Dhaka using Horiba Pentra DX Nexus automated haematology analyzer. Statistical analysis was performed by using SPSS (Statistical Package for Social Sciences) Version 16. Data were presented as mean and standard deviation (mean \pm SD). Unpaired Student's 't' test was done to compare between the groups and correlation was analyzed by Pearson's correlation co-efficient (r) test. *p* value of < 0.05 was taken as level of significance.

Result

In this study no statistical differences were observed in age, BMI, socioeconomic condition, systolic and diastolic blood pressure between groups (Table I). Hemoglobin concentration and total count of RBC were significantly lower in the cement dust exposed subjects in comparison to the control group (Table II). Nineteen study subjects (41%) exposed to cement dust had mean hemoglobin concentration less than 13.0 g/dL. Among them, significantly lower mean hemoglobin concentration was observed in subjects in the age range of 20-35 years who were exposed for 7-12 years. Twenty seven cement dust exposed subjects had mean hemoglobin concentration within normal range (≥ 13.0 g/dL). Among them, significantly lower mean hemoglobin concentration was noted in subjects in the age range of 36-50 years who were exposed for 7-12 years (Table III). Hemoglobin concentration showed negative correlation with duration of cement dust exposure, which was statistically significant ($p < 0.001$) (Figure 1).

Table I : General characteristics of the subjects in both groups (N=92)

| | Cement factory workers(n=46) | Control (n=46) |
|---------------------------------------|--------------------------------|--------------------|
| Age (years) ^a | 33.17 \pm 8.27 ^{ns} | 33.52 \pm 7.87 |
| BMI (kg/m ²) ^a | 23.14 \pm 2.06 ^{ns} | 23.71 \pm 2.61 |
| Socioeconomic condition | | |
| Low | 46 (100%) | 46 (100%) |
| Systolic BP (mmHg) | 117.72 \pm 15.06 | 113.04 \pm 12.09 |
| Diastolic BP (mmHg) | 71.74 \pm 9.51 | 70.87 \pm 9.11 |

Data shown as Mean \pm SE, Statistical analysis was done by Unpaired Student's 't' test,

Control=Healthy adult subjects not exposed to cement dust, BMI=Body mass index,BP= blood pressure.

Table II: Hb% & TC of RBC of the subjects in both groups (N=92)

| Parameters | Cement factory workers (n=46) | Control (n=46) |
|--|---------------------------------|------------------|
| Hb concentration (g/dL) ^a | 12.91 \pm 1.84 ^{***} | 14.40 \pm 1.23 |
| RBC count (x 10 ⁶ / μ l) ^a | 4.79 \pm 0.84 ^{**} | 5.18 \pm 0.48 |

Data were shown as mean \pm SE .Statistical analysis was done by Unpaired Student's 't' test. N= total number of subjects. Hb= hemoglobin, RBC= red blood cell, (* Cement factory workers vs Control group) *** = $p < 0.001$, ** = $p < 0.01$. n= number of subjects in each group

Table III: Comparison of mean hemoglobin concentration with age and duration of cement dust exposure (N=46)

| Age (years) | Hb concentration in study group (g/dL) | | | |
|-------------|--|---------------------------------|------------------|--------------------------------|
| | <13.0 | | ≥ 13.0 | |
| | Duration of dust exposure | | | |
| | 2-6 years(n=6) | 7-12 years(n=13) | 2-6 years(n=16) | 7-12 years(n=11) |
| 20-35(n=29) | 12.00 \pm 0.50 | 10.05 \pm 0.35 ^{***} | 14.86 \pm 0.63 | 13.51 \pm 0.30 ^{ns} |
| 36-50(n=17) | - | 10.95 \pm 0.90 | 15.00 \pm 0.50 | 13.35 \pm 0.05 [#] |

Data were shown as mean \pm SE .Statistical analysis was done by Unpaired Student's 't' test (a) for comparison between groups. Study group= study subjects exposed to cement dust, n= total number of subjects in each group. Hb= hemoglobin, *** = $p < 0.001$,# = $p < 0.05$, ns= not significant .

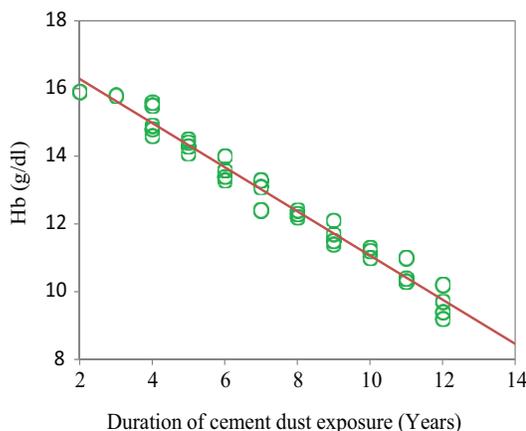


Figure 1: Correlation of hemoglobin concentration with duration of cement dust exposure in study group presenting there is negative correlation between hemoglobin concentration and duration of cement dust exposure. Hb= hemoglobin concentration.

Discussion

In the present study, mean hemoglobin concentration and total count of RBC were lower in subjects exposed to cement dust than that of controls. This result is similar to others ^{2,14}. Negative correlation was observed between the hemoglobin concentration and duration of cement dust exposure. Similar findings were observed in other studies ^{14,15}. Literature review suggested that chronic exposure to toxic components of cement dust (crystalline silica, hexavalent chromium, calcium oxide, aluminium) induce inflammation with accumulation of neutrophils, macrophage and lymphocytes in the lung. Very small particles like cement dust (diameter range of 0.05µ and 5.0 µ) can also pass into circulation ^{2,16,17}.

Phagocytosis of silica by alveolar macrophage gives rise to increased oxygen consumption, production of superoxide anion (O_2^{\bullet}), H_2O_2 , and increased NO^{\bullet} synthesis. Free radical damage to

cells result in cascade of cellular responses such as pro-inflammatory cytokine like tumor necrosis factor- α (TNF- α), interleukins (IL-1, IL-8) release and activation of transcription factor such as nuclear factor κ -B and activator protein-1 ^{6,18}. Both NF- κ B and TNF α inhibit globin genes expression. This may result in decreased globin formation and hemoglobin production ¹⁹.

Crystalline silica found in cement dust has a silanol group on its surface. This silanol group can form hydrogen bond with the nitrogen and oxygen group of biological membranes and may produce H_2O_2 in large quantity. This H_2O_2 causes Hb denaturation and leads to cell membrane rupture. H_2O_2 reacts with metal ions such as iron (Fe^{2+}) present in hemoglobin to form hydroxyl radical by Fenton reaction. The reaction results in conversion of oxyhemoglobin having Fe^{2+} to methemoglobin having Fe^{3+} in red blood cells and hydroxyl ion causes lipid peroxidation of red blood cell membrane ^{6,20}.

Transcription factor GATA-1 is essential for survival of erythroid progenitors as well as the terminal differentiation of erythroid cells. TNF α , produced by alveolar macrophage upon cement dust exposure, causes inhibition of GATA-1. Down regulation of GATA-1 inhibits erythropoiesis. This may result in decrease in red blood cells ¹⁷.

Conclusion

After analyzing the results of the study, it can be concluded that exposure to cement dust has deleterious effect on the hemoglobin concentration and total count of RBC. Moreover the duration of cement dust exposure has an impact on the hemoglobin concentration

Conflict of Interest None

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