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Human Mercury Exposure Associated with Artisanal Gold Miners in Sudan

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Abstract

Background: Mercury concentration in the blood is one of mercury exposure biomarkers. This study was conducted in Abuhamed mining area in Sudan, during the period from August 2012 to November 2014.The aim of the study was to evaluate serum mercury levels and to assess lung functions in artisanal gold miners.

Methods: The study included 123 subjects, of them 83 were working in the gold mining area, beside 50 healthy volunteers from Khartoum State, as control group. Serum mercury was measured by direct mercury analyzer (DMA-80). Lung function tests were done with a portable spirometer. Data were analyzed using IBM SPSS Statistics version 20.

Results: The study observed significant increase in serum mercury levels in the gold miners, when compared with control group (24.9 ± 32.24µg/l) versus (1.40 ± 0.94µg/l) with P value (0.000). The mean forced expiratory volume in the first second (FEV1) in the gold miners was (3.24 ± 0.57) versus (3.40 ± 0.39) in the control group, while the mean forced vital capacity (FVC) in the mercury exposed miners was (3.7 ± 0.69) versus (3.86 ± 0.60) in non-exposed control group.

Conclusion: Serum mercury levels significantly increase in the traditional gold miners working in Abuhamed, while forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC) decrease but with no statistical significance.

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Introduction

Mercury (Hg) is a ubiquitous and highly toxic environmental pollutant [1]. It is found in three forms with different toxicities: elemental, inorganic and organic [2]. One of the most common uses of mercury is for the extraction of gold from gold-containing ores [3]. Mercury alters the physiological and the biochemical functions of living organisms, and causes a wide range of clinical symptoms in occupationally exposed workers [4,5]. Mercury exposure is a health concern in the occupational settings like gold mining [6]. In artisanal small scale gold mining sites, the heating of the gold-mercury mixture with little or no personal protection, results in the evaporation of mercury and exposures through inhalation [7]. The vapor emitted from metallic mercury is a potent neurotoxic agent [8]; this vapor is a colorless and odorless substance [9]; approximately 80% of it is absorbed via the lungs [10]. The target organs for inhaled elemental mercury are primarily the brain, the kidney and the lung [8]. The harmful impacts of mercury include neurotoxicity, immunosuppression, myocardial infarction, autism and Alzheimer [11,1]. Mercury is poorly absorbed in the gastrointestinal tract, but skin absorption is insignificant in relation to human exposure to mercury vapour [10]. Even at extremely low exposures, mercury can cause permanent damage to the human central nervous system [12,13]. Gaseous phase of heated mercury; causes acute interstitial pneumonia when inhaled at a high concentration [7]. Chronic mercury toxicity also causes tremor, unsteady gait, irritability, poor concentration, short-term memory deficits, tremulous speech, blurred vision, performance decrements, paresthesia, and decreased nerve conduction [14]. Skin sensitivity reactions occur more often in persons who have been chronically exposed to organic rather than inorganic mercurials [15]. Blood is considered a good biomarker of short-term mercury exposures [16].

In recent years after referendum of Southern Sudan, most of the petroleum income was lost in Sudan; as a result nearly millions of Sudanese were forced to work in artisanal gold mining especially in River Nile State, using traditional means for extracting the gold from ores. This study was done to evaluate the occupational exposure for mercury among these miners.

Material and Methods

This study was conducted in Abuhamad gold mining area in River Nile State-Sudan in the period between August 2012 to November 2014. The study included 83 traditional gold miners; all of them were males; beside 50 age matched males; apparently healthy from Khartoum State, served as control. The clinical examination was done by a chest physician. The traditional gold miners included in this study, have been in the mining area in the desert, for more than 6 successive months. They were living in small camps nearby working area, which included wells, stone mills, washing and molding. The washing performed in water pools where gold is mixed with mercury and then the mixer heated in small metal pans directly in the air. Bare hands, feet and faces were seen in all the processes. The control group has never been in mining areas. Blood specimens were collected from the all the subjects under study in sterile conditions into sterile plain containers and the serum was separated by centrifugation into another plain container, and then stored at -70°C till the time of analysis. Assessing of the lung functions was done using portable spirometer for the two groups. Serum mercury was measured using direct mercury analyzer (DMA-80). Data were analyzed using IBM SPSS Statistics version 20.

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Results

The study revealed that the serum mercury in the traditional gold miners was (24.9 ± 32.24µg/l) versus (1.40 ± 0.94µg/l) in the non-exposed control group; with p value (p= 0.000) Table 1. The mean age was (30.46 ± 10.01 years) in gold miners, versus (28.10 ± 5.39 years) in non-exposed control men. The mean weight was (63.14 ± 10.51 kg) in gold miners, versus (63.00 ± 10.96 kg) in non-exposed normal subjects. The mean height was (169 ± 6.44 cm) in gold miners, versus (168.45 ± ± 6.46cm) in the control subjects. The prevalence of smoking was 42 (50.6%) among gold miners; while it was 25 (50%) among control group.The mean forced expiratory volume in the first second (FEV1) in the gold miners was (3.24 ± 0.57) versus (3.40 ± 0.39) in the control group, with no statistical significance, while the mean forced vital capacity (FVC) in the mercury exposed miners was (3.7 ± 0.69) versus (3.86 ± 0.60) in non-exposed control group, with no statistical significance. In the miners group; 37(44.6%) worked in wells, 27(32.5%) worked in mills, 14(16.9%) worked in washing and 5(6.0%) worked in the modiling. The clinical symptoms complained by the traditional gold miners were coughing 35(42.2%), headache 31(37.3%), excessive sputum production 28(33.7%), dizziness 27(32.5%), chest pain 26(31.3%), shortness of breath (SOB) 25(30.1%), weight loss 22(26.5%), wheezing 17(20.5%), hemoptysis 6(7.2%), beside burning micturition 31(37.3%) and constipation 17(20.5%) Table 1.

Parameters	Traditional gold miners (n=83) (Mean ± Std)	Non exposed healthy controls (n= 50) (Mean ± Std)	P value
Age (years)	30.46 ± 10.01	28.1 ± 5.39	
Weight (kg)	63.14 ± 10.51	63.00 ± 10.96	
Height (cm)	169 ± 6.44	168.45 ± 6.46	
Mean FEV1 (L)	3.24 ± 0.57	3.40 ± 0.39	
Mean FVC (L)	3.7 ± 0.69	3.86 ± 0.60	
Mercury (Hg) (µg/l)	24.9 ± 32.24 Range (0.86–124µg/l)	1.4 ± 0.94 Range (0.29–3.6 µg/l)	0.000

Table 1: The study of age, forced expiratory volume in 1st second (FEV1), forced vital capacity (FVC)and serum mercury (Hg) levels in traditional gold miners and non-exposed healthy control men.

Discussion

A serum mercury concentration is one of mercury exposure biomarkers. Human absorption of liquid Hg0 is minimal, and acute toxicity does not occur easily, but the problem arises when liquid mercury is heated and bursts into the gaseous phase, which causes acute interstitial pneumonia when inhaled at a high concentration. In the present study the traditional gold miners, work in a hot climate in a deserting area. As seen in the field; Sudanese traditional gold miners do not take any safety measure when dealing with mercury, even gloves or masks. They treat the mercury as if; non-toxic substance; especially in washing stage to extract gold from washed stoned powder, and when heating the gold-mercury mixture to evaporate mercury and remain gold in metallic pans. The second source of exposure is that all the serious stages occur in the same area not exceeding few meters between stone milling, washing and modling. The third factor is low occupational awareness among the traditional gold miners. These reasons accumulated together, to find that the serum mercury among the exposed men is nearly eighteen folds than in non-exposed men or (24.9 ± 32.24µg/l) versus (1.40 ± 0.94µg/l). This means that these miners and their families are exposed to dangerously high levels of mercury in the workplace. Similar finding was also reported earlier in Brazil by [17] and in Iran by [6]. These gold miners complain from multi symptoms like persistent cough, headache, dizziness, chest pain, shortness of breath, wheezing and even hemoptysis. These health effects may be associated with repeated exposure to mercury, which influence enzymes, cell membrane and neuron functioning as reported by [18]; most of the above clinical signs especially cough, headache, dizziness, muscle weakness were also reported in artisanal gold miners in Bukina Faso by [19], and Indonesia by [20]. This study is the first of our knowledge, to kind serum mercury levels, and to investigate the association of Hg and the pulmonary functions in the small-scale gold miners in Sudan.

Conclusion

Serum mercury levels significantly increase in the traditional gold miners working in Abuhamed, River Nile State, while forced expiratory volume in the first second (FEV1) and forced vital capacity (FVC) and forced expiratory volume decreasebut with no statistical difference. Occupational exposure to mercury is prevalent among traditional gold mining workers in Sudan. Medical surveillance for all artisanal gold miners, including, quarterly and semiannual serum mercury assessment, and self-safety measures should be adopted.

Limitation

In this research even the spirometer work was performed by one trained doctor; but many others factors affect the clinical value of spirometer results, as reported by [21]. For example when the patient blows into a 'cold' spirometer, the volume recorded by the spirometer, in this case is less than that displaced by the lungs. In the current research the hot temperature surrounded the miners, in the desert in the midday of summer was quite different from that of the control group in the Khartoum in cooled room. Other confounding factors like smoking in the two groups may have role in the significance of lung function in this study.

Competing Interests

The authors declare that they have no competing interests.

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