Blood lead level, plasma malondialdehyde level and plasma vitamin C level in lead-exposed battery workers

Cherry Bo Htay♦, Aye Thapyay Win★, Ohnmar❖

Abstract

Lead exposure causes oxidative stress which is one of the key mechanisms associated with impairment of the various body functions in the battery workers as occupational risks. The aim of the present study was to determine and compare the blood lead level (BLL), plasma malondialdehyde (MDA) level and plasma vitamin C level between the non-exposed subjects and lead-exposed battery workers, and to find out the relationship among these three parameters in the lead-exposed male battery workers. This study was a cross-sectional analytical study carried out in 28 non-exposed male subjects and 28 lead-exposed male battery workers in small scale battery workplaces in Insein and North Okkalapa Townships. BLL was determined by graphite furnace atomic absorption spectrometric method, plasma MDA by spectrophotometric method and plasma vitamin C by a simple colorimetric method. Lead-exposed battery workers had significantly higher BLL than the non-exposed subjects (4.25 ± 3.87 vs 2.14 ± 1.02 μg/dL: $P < 0.01$). The mean plasma MDA was significantly higher ($P < 0.001$) in the lead-exposed battery workers (2.08 ± 0.94 μmol/L) than that of the non-exposed subjects (0.9 ± 0.43 μmol/L). Correlation study in the lead-exposed battery workers showed a significant negative correlation between plasma MDA level and plasma vitamin C level ($r = -0.51$, $n = 28$, $P < 0.01$). It was concluded that even low lead level exposure increases the level of a marker of oxidative stress, and that vitamin C might be involved as "antioxidant defense" in the lead induced oxidative stress.

Introduction

Lead is one of the oldest known toxic metals for man. Exposure to lead occurs in industrial workers during battery repairing, paint manufacturing and construction works involving demolition and renovation[1]. Primary contributory factor in the pathogenesis of adverse health effects is lead-induced oxidative stress through generation of reactive oxygen species (ROS)[2]. Some in-vitro and in-vivo studies showed that an elevated production of ROS leads to increased lipid peroxidation associated with altered antioxidant defense systems[3].

♦ Assistant Lecturer, Department of Physiology, University of Medicine 1, Yangon
★ Lecturer, Department of Physiology, University of Medicine 1, Yangon
❖ Professor and Head, Department of Physiology, University of Medicine 1, Yangon

Malondialdehyde (MDA) is a clinical marker of oxidative stress, specifically due to disruption of cell membrane lipid bilayer, which is capable of inactivating many cellular proteins. In lead-exposed workers, blood lead level was significantly correlated with plasma MDA level[4,5]. In addition, in the study of battery manufacturing workers of Western Mahrashtra in India, serum MDA level of the workers was significantly increased compared to that of non-exposed workers[6].

Some human studies also found the role of vitamin C in lead-induced oxidative stress. A cross sectional study conducted in Korea found a significant decrease in serum vitamin C level in lead storage battery workers compared to non-exposed group[7]. In a study of battery workers in Iraqi storage battery plant, treatment with antioxidants including vitamin C for one month caused a significant increase in reduced glutathione (GSH), the antioxidant enzyme, compared to pretreatment levels[8]. This may be due to direct scavenging activities on the generated ROS and decreased utilization and damage of GSH or indirect effect through the improvement of the oxidant/antioxidant balance in the cells after treatment[9].

The present study focused on lead-induced oxidative stress and antioxidant defense in the lead-exposed battery workers compared with the non-exposed subjects.

Material and Method

A cross-sectional analytical study was carried out from April 2015 to February 2016. Male workers from small scale battery workplaces in Insein and North Okkalapa Townships (n = 28) and apparently healthy non-exposed male subjects (n = 28) from University of Medicine 1, Pyay Campus and Lanmadaw Campus were recruited. They were explained about the experiments and then written informed consents were obtained. History taking and physical examination including anthropometric assessment were done. They were instructed to take 10 hour-overnight fasting, starting from 10:00 pm to 8:00 am. Blood samples from battery workers were taken at 8:00 am on the next morning at the workplace.

About 8 ml of blood was withdrawn from antecubital vein under aseptic condition. Blood was collected in three separate test tubes: 4 ml of blood was delivered gently into heparinised tube for blood lead level (BLL) determination and another 2 ml of blood was delivered into anticoagulant (EDTA) containing acid treated tube for plasma MDA assay. Another 2 ml of blood was delivered into tube containing potassium oxalate for plasma vitamin C level determination. Blood samples for MDA and vitamin C were centrifuged at 3000 rpm for 10 minutes. After centrifugation, the plasma MDA and plasma vitamin C levels were determined within 6 hours from the time of sample collection.

Statistical Analysis

Data were presented as mean ± SD. Data analysis was done by using the Statistical Package for Social Sciences (SPSS) software version 16. The difference between the means of the lead-exposed battery workers and non-exposed subjects was assessed by Student's *t* test. Pearson's correlation coefficients were computed to explore strength and significance of the relationships among variables. The statistical significance level was set at $P < 0.05$.

Results

Baseline characteristics of the lead-exposed battery workers and non-exposed subjects are shown in Table - 1.

Table - 1. Baseline characteristics of the subjects

Parameter	Lead-exposed battery workers (n = 28)	Non-exposed subjects (n = 28)	P Value
Completed age (years)	27.8 ± 9.19	27.8 ± 9.23	NS
Weight (kg)	56.74 ± 10.2	53.05 ± 9.32	NS
Height (m)	1.63 ± 0.07	1.63 ± 0.07	NS
Body mass index (kg/m^2)	21.29 ± 3.08	20.03 ± 2.77	NS
Resting heart rate (beats/minute)	74.9 ± 6.00	78.8 ± 3.82	0.006
Resting systolic blood pressure (mmHg)	117.5 ± 6.94	118.5 ± 5.59	NS
Resting diastolic blood pressure (mmHg)	72.9 ± 5.06	74 ± 5.47	NS
Duration of lead exposure (years)	5.4 ± 7.02	-	-

- Data are presented as mean ± SD
- NS = no significant difference

Mean blood lead level and plasma MDA levels of the lead-exposed battery workers were statistically higher than those of the non-exposed subjects (Table-2). There was no significant difference in plasma vitamin C levels in the lead-exposed battery workers and non-exposed subjects (1.04 ± 0.61 mg/dL vs 1.27 ± 0.47 mg/dL). A significant negative correlation was observed between plasma MDA level and plasma vitamin C level in the lead-exposed battery workers (r = - 0.51, n = 28, P = 0.006), but this relationship was not found in the non-exposed subjects (r = - 0.097, n = 28, P = 0.623) (Figures 1 and 2).

Table - 2. Blood lead level, plasma MDA level and plasma vitamin C level of the lead-exposed battery workers and non-exposed subjects

	Lead-exposed battery workers (n = 28)	Non-exposed subjects (n = 28)	P Value
Blood Lead Level (µg/dL)	4.25 ± 3.87	2.14 ± 1.02	P < 0.01
Plasma MDA level (µmol/L)	2.08 ± 0.94	0.9 ± 0.43	P < 0.001
Plasma Vitamin C level (mg/dL)	1.04 ± 0.61	1.27 ± 0.47	NS

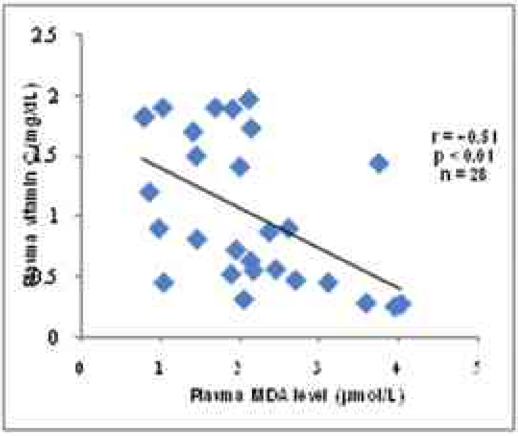

Figure - 1. Correlation between plasma MDA level and plasma vitamin C level of the lead-exposed battery workers

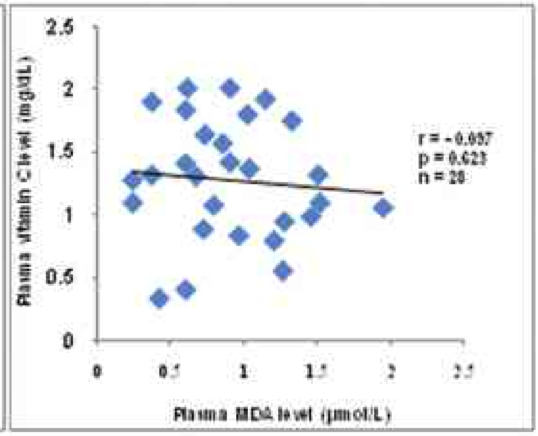

Figure - 2. Correlation between plasma MDA level and plasma vitamin C level of the non-exposed subjects

Discussion

In the present study, the mean BLL of the lead-exposed battery workers (n = 28) was 4.25 ± 3.87 µg/dL with the lowest being 0.9 µg/dL and the highest being 16.4 µg/dL. The mean BLL of the non-exposed subjects (n = 28) was 2.14 ± 1.02 µg/dL, with the lowest being 0.9 µg/dL and the highest being 4.4 µg/dL. According to Centers for Disease Control and Prevention (1991), BLL of 10 µg/dL was considered safe. Blood lead level of all participants except two lead-exposed battery workers were found to be lower than 10 µg/dL. In addition, it was found that mean BLL of both non-exposed and lead-exposed battery workers in the present study were lower than those of previous studies carried out in Myanmar; mean BLL of control subjects and battery workers were 6.98 ± 2.18 µg/dL and 48.45 ± 19.96 µg/dL (Zarli-Thant, 2005) and 19.83 ± 4.7 µg/dL and 80.21 ± 28.63 µg/dL (Wah-Wah-Tin, 2007) respectively.

As lead is a well-known toxic metal, reduction in the use of lead in petrol (gasoline), paint, plumbing and solder resulted in substantial reduction in blood lead levels in African rural population[13]. In Myanmar, imported sealed type batteries are becoming more popular and available. The participants in the present study work in small scale battery shops. The small battery shops just need to repair and recycle instead of manufacturing. Therefore, lower BLL compared with the previous studies might probably be due to lesser handling and exposure to lead.

In the present study, mean BLL of the lead-exposed battery workers was statistically higher than that of the non-exposed subjects. This finding is consistent with findings of previous studies carried out in Myanmar[11,12] as well as in other countries[14]. In fact, the ideal level of BLL is 0 µg/dL and maximal acceptable level is 10 µg/dL. In the present study, the non-exposed subjects (n = 28) had BLL in a range of 0.9 - 4.4 µg/dL indicating that they had low lead exposure. Since lead is ubiquitously present in the environment, non-occupational exposure can occur via contaminated air, food, water and soil[15]. Apart from battery workplaces, people can get lead exposure through lead contaminated water, food and beverages in which contaminant cannot be seen, tasted or smelled. Lead may still be found in some commercial products.

In the present study, it was found that plasma MDA level of the lead-exposed battery workers were significantly higher than that of the non-exposed subjects ($P < 0.001$). Similar findings were reported by Al-Ubaidy *et al*. (2006) and Khan *et al*. (2008). The observed significant increase in plasma MDA level in the lead-exposed battery workers indicated oxidative stress which might be due to an increased production of the reactive oxygen species (ROS). Previous in-vitro and in-vivo studies demonstrated that lead exposure increases ROS production[16,17,18]. According to Knowles and Donaldson (1990), lead-induced membrane oxidative damage in chicks was due to changes in the fatty acid compositions resulting in altered membrane integrity, permeability and function, with increased susceptibility to lipid peroxidation[19].

The plasma vitamin C level in the lead-exposed battery workers and non-exposed subjects were 1.04 ± 0.61 mg/dL and 1.27 ± 0.47 mg/dL respectively. Normal range of plasma vitamin C is 0.6 - 2 mg/dL[20]. 64.3% of lead-exposed battery workers and 89.3% of the non-exposed subjects had normal plasma vitamin C levels. A significant negative correlation between plasma MDA level and plasma vitamin C level in the lead-exposed battery workers suggested that vitamin C might be involved as "antioxidant defense" in the lead induced oxidative stress.

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