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Blood Lead Level and Cardiovascular Risk Factors among Bus Drivers in Bangkok, Thailand

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Abstract: This study aimed to clarify the role of blood lead level (Pb-B) as one of the cardiovascular risk factors. To evaluate the cardiovascular risk the second derivative finger photoplethysmogram (SDPTG) was used. The subjects comprised of 420 male bus drivers in Thailand. The subjects' age ranged from 20 to 60 yr. Mean age (± standard deviation) were 41.6 (± 7.7) yr. Mean working years was 8.8 (± 6.8) yr. Pb-B ranged from 2.5 to 16.2 μg/dl with the mean Pb-B of 6.3 (± 2.2) μg/dl. The mean of aging index of SDPTG (SDPTG-AI) were –0.50 (± 0.30). The SDPTG-AI increases with age, Pb-B, smoking and alcohol consumption. There was significant correlation between Pb-B and SDPTG-AI after controlling for age, body mass index and lifestyle factors. These results suggest that Pb-B is possibly an independent cardiovascular risk factor for bus drivers exposed to lower level of lead.

Key words: Blood lead, SDPTG, Cardiovascular system, Risk factor, Bus drivers

Introduction

The occupational exposure to low level of lead in environmental setting introduces dysfunctions of cardiovascular system[1–4]. Some researchers have reported significant relationships between blood lead at low levels and cardiovascular and/or peripheral arterial disease[5, 6], impaired renal function, and elevated blood pressure[7–12].

Bus drivers are one of the groups who are long term occupationally exposed to lead, especially when driving a bus in Bangkok, Thailand with its heavy traffic congestion. Our previous report[13] revealed that blood lead level (Pb-B) increased blood pressure (BP) of bus drivers even the exposure level was low (0.22 μg/m^3). Increased BP is one of cardiovascular risk factors. However, it is still not clear whether Pb-B is an independent risk factor or the one depending on increased BP.

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The aim of this study was to clarify the independent role of Pb-B as one of the risk factors. To evaluate the cardiovascular risk the second derivative finger photoplethysmogram waveform (SDPTG) is used.

Subjects and Methods

Subjects

Subjects in this study were 444 male bus drivers who had worked in the Bangkok Mass Transit Authority at zone 7 located in Bangkok. The subjects' age ranged from 20 to 60 yr.

The subjects were individually interviewed on their personal and medical histories, work experience, and lifestyle factors, such as current smoking status, alcohol consumption and physical exercise. Smoking status was categorized into two groups: current smoking and never or quit smoked. Alcohol consumption status in the previous year was asked and classed into two groups: regular alcohol drinking (three times or more per week) and no drink-

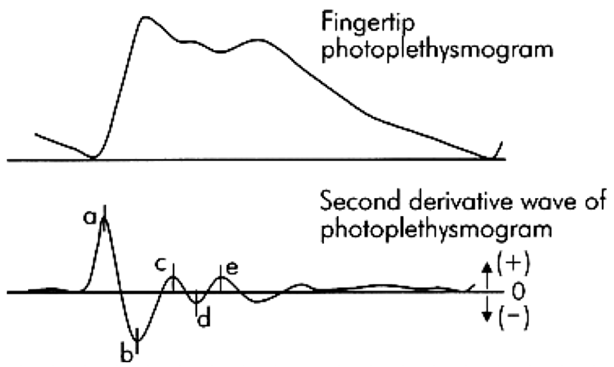

Fig. 1. Measurements of fingertip photoplethysmogram and its second derivative wave (SDPTG).

ing (less than three times per week). Concerning physical exercise the status was divided into the group of exercise (two times per week) and lack of exercise (less than two times per week). All subjects gave a signed informed consent.

The subjects who had a history of hypertension, heart disease, or diabetes were excluded, as were subjects whose SDPTG could not be measured due to tachycardia. Thus, 420 male bus drivers were finally included in this study. Mean age (± Standard Deviation: SD) was 41.6 (± 7.7) yr. Mean working years was 8.8 (± 6.8) yr.

Measurements of SDPTG

A digital photophethysmograph (FCP-3166, Fukuda Denshi, Tokyo, Japan) was used to record the SDPTG. Each subject was rested for about 15 min before the SDPTG was measured in supine position at the second fingertip of left hand. The temperature in the testing room was kept at 23–25°C.

The schema of the curves obtained in SDPTG is shown in Fig. 1. The SDPTG waveform consists of four systolic waves and one diastolic wave: an initial positive wave (a wave), an early negative wave (b wave), a second positive wave (c wave), a second negative wave (d wave) and a diastolic positive wave (e wave). The a and b waves correspond to the early systolic component of SDPTG, and the c and d waves correspond to the late systolic component[14]. We measured the height of the a, b, c, d, and e waves from the baseline, with the values above the baseline being positive and those below it negative, and then calculated the SDPTG aging index (SDPTG-AI) by the ratios of (b–c–d–e)/a. This index is to show the cardiovascular risk[15]. Higher values of SDPTG-AI indicate lower central and peripheral arterial functions.

Body height, body weight and body mass index

All subjects took off their shoes before body weight (BW) and height (BH) were measured by using manual scale. Body Mass Index (BMI) was calculated as body weight (kg) divided by square of height (m^2).

Blood pressure measurements

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate (PR) were measured using a digital blood pressure monitor (HEM-907, Omron, Tokyo, Japan) on the right arm in the supine position after resting at least for 15 min. An average of 3 continuing measurements was used to get a representative value. Mean blood pressure (MBP) was calculated as DBP + (SBP – DBP)/3.

Blood lead measurements

Venous whole blood specimens were collected in a lead free heparinised vacutainer with bus drivers. Each sample stored at 4°C was sent to the laboratory for Pb-B analysis. The detail information on measuring Pb-B is referred in our previous report[13].

Statistical analyses

Data were expressed as mean (± SD) and percentage. Differences in mean and percentage of study variables between two groups were examined by using Student's *t* test and χ^2 test, respectively. Pearson's correlation analysis was used to examine the association among study variables. A multiple regression analyses (forward stepwise) was used to determine the significant and independent correlates for SDPTG-AI. The following factors were included in the model as independent variables; age, BMI, smoking, alcohol consumption, physical exercise and Pb-B. The statistically significant criterion was set at $p<0.05$. All statistical analyses were conducted using the SPSS statistical package V. 6.1 for Windows[16].

Results

The general characteristics of the study subjects are shown in Table 1. The mean of aging index of SDPTG (SDPTG-AI) were –0.50 (± 0.30). The mean Pb-B were 6.3 (± 2.2) μg/dl. The subjects were divided into two subgroups according to their Pb-B. They were assigned into the low group if their Pb-B was less than mean –SD (4.1 μg/dl) and into the high group if their Pb-B was mean + SD (8.5 μg/dl) and more. Table 2 shows the comparison of study variables between the high and low Pb-B subgroups. There was significant difference in SDPTG-AI and MBP, although no significant difference was obtained in age, BMI and years of work between the two subgroups.

Figure 2 shows the distributions of the Pb-B. Pb-B ranged between 2.5 to 16.2 μg/dl. The values had logarithmically normal distribution. Consequently, log-transformed values of Pb-B were used for analyses in this study.

The correlation matrix among study variables is shown in Table 3. All variables except BH showed significant correlation with SDPTG-AI.

Table 4 shows the mean and SD of SDPTG-AI classified by lifestyle factors. The means SDPTG-AI in subjects who were smoking and drinking were significantly higher than those in the subjects who were not. No different of SDPTG-AI was observed between the subjects who did exercise and those who did not.

The results of stepwise multivariate linear regression

Table 1. Characteristic of the subjects

Variables	Bus driver (n=420)
	Mean (SD)
Age (yr)	41.6 (7.7)
Body weight (kg)	64.7 (11.0)
Body height (cm)	164.9 (6.0)
BMI (kg/m^2)	23.8 (3.6)
SBP (mmHg)	130.9 (16.8)
DBP (mmHg)	81.0 (11.1)
MBP (mmHg)	97.2 (12.6)
PR (beat/min)	74.6 (10.5)
SDPTG	–0.50 (0.30)
Pb-B (μg/dl)	6.3 (2.2)
Working career (yr)	8.8 (6.8)
	n (%)
Smoking	197 (44.9)
Alcohol consumption	287 (65.4)
Lack of exercise	195 (44.4)

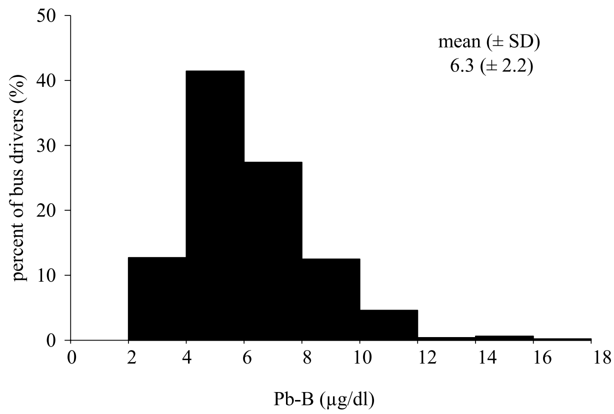

Fig. 2. Distributions of lead concentrations in blood in bus drivers in Bangkok, Thailand.

Table 2. Mean and SD of age, BH, BW, BMI, SBP, DBP, MBP, SDPTG-AI, and years of work in high and low Pb-B groups

Variables	Low group (n=54)	High group (n=83)	*p*-value
	Mean (SD)	Mean (SD)	
Age (yr)	42.7 (7.9)	43.2 (7.9)	0.722
BH (cm)	164.9 (6.4)	164.9 (5.7)	0.975
BW (kg)	64.9 (10.6)	63.6 (10.6)	0.489
BMI (kg/m^2)	23.8 (3.4)	23.3 (3.3)	0.423
SBP (mmHg)	127.5 (13.9)	136.3 (18.8)	0.004
DBP (mmHg)	78.1 (9.0)	84.9 (11.6)	0.000
MBP (mmHg)	94.6 (10.3)	102.0 (13.4)	0.001
SDPTG-AI	–0.56 (0.30)	–0.42 (0.30)	0.015
Working years (yr)	10.5 (7.2)	10.1 (7.5)	0.755

Table 4. Mean and SD of SDPTG-AI classify by lifestyle

Lifestyle		*p*-value
Smoking	No-smoking	
–0.44 (0.21)	–0.55 (0.23)	0.000
Alcohol	No-alcohol	
–0.40 (0.31)	–0.53 (0.20)	0.000
Non-exercise	Regular exercise	
–0.49 (0.21)	–0.54 (0.31)	NS

Table 3. Pearson's correlation coefficients among study variables

	BW	BH	BMI	SBP	DBP	MBP	PR	SDPTG-AI	Log Pb-B
Age	0.124*	–0.072	0.205**	0.358**	0.333**	0.356**	0.100*	0.473**	0.078
BW		0.433**	0.902**	0.253**	0.232**	0.252*	0.115*	–0.119*	–0.039
BH			0.006	0.012	–0.053	–0.027	–0.012	–0.090	–0.004
BMI				0.291**	0.281**	0.296**	0.144**	–0.0.17**	–0.025
SBP					0.862**	0.954**	0.243**	0.385**	0.186**
DBP						0.974**	0.318**	0.411**	0.205**
MBP							0.296**	0.414**	0.204**
PR								–0.099*	0.047
SDPTG-AI									0.185**

*p<0.05, **p<0.01.

Table 5. Factors associated with SDPTG-AI in stepwise multiple regression analysis

Variables	β	p value	Adjusted R^2
Age	0.020	0.000	0.215
BMI	–0.011	0.004	0.239
Pb-B	0.017	0.003	0.254
Smoke	0.066	0.015	0.263

analysis are shown in Table 5. The SDPTG-AI independently correlated with Pb-B as well as age, BMI and smoking.

Discussion

The results in this study suggest that the Pb-B is possibly an independent cardiovascular risk factor in bus drivers exposed to lead even if it was adjusted by age, BMI and lifestyle factors. The bus drivers had been occupationally exposed to lead. The lead is now prohibited to mix into the gasoline in Thailand[13]. As the results, the exposure level of lead has decreased in bus drivers.

The bus drivers had dose-dependently higher SDPTG-AI, although they had Pb-B at low level. The SDPTG-AI independently correlated with Pb-B even if it was adjusted by age, BMI and smoking. These results indicate the possibility that Pb-B works independently as a cardiovascular risk factor in bus drivers.

SDPTG has been introduced to use for assessment of arterial properties[11]. Although obtained from the periphery of circulation, SDPTG provides information about both central and peripheral arterial properties. Indices of SDPTG closely correlate with age and other cardiovascular risk factors[11–15] and sensitive to detect the dysfunction arterial properties. In this study, therefore, SDPTG was affected even by low level of Pb-B in bus drivers.

Earlier studies have reported the effect of Pb-B on cardiovascular functions, such as blood pressures and peripheral blood flow[2–4, 7]. Finger blood flow decrease among workers exposed to lead[5]. Pb-B effected peripheral hemodynamics among workers exposed to lead as evaluated by acceleration plethysmography[6]. The results of this study support such results.

In our study SDPTG-AI increased with age and poor lifestyle in terms of cigarette smoking and alcohol drinking. This result was consistent with the report of Takazawa *et al*[11]. They have reported that SDPTG-AI increased with increasing age and that SDPTG-AI was higher in the subjects with any history of cardiovascular risk than in age-matched subjects without such a history.

These results suggest the possibility that Pb-B is the independent cardiovascular risk factor in bus drivers exposed to lower level of lead. Pb-B is measured with workers in the industries which treat the lead such as battery plants[17, 18]. In such industries, it is important to note that Pb-B is one of the cardiovascular risk factors, even if the level in environment is low.

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