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Motor Nerve Conduction Velocity (MCV) and Lead Content in Sciatic Nerve of Lead-Exposed Rats

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There have been many pathological and electrophysiological studies of peripheral nerves in inorganic lead intoxication (Tsuchiya 1979). Pathologically, lead causes demyelination and/or axonal degeneration in the peripheral nervous system of animals and mainly axonal degeneration in humans (Buchthal and Behse 1981; Waldon and Stöfen 1974). Peripheral nerve conduction velocity (NCV) has been used as an objective measure of the effects of lead on the peripheral nerve function and has been examined with blood lead content (Buchthal and Behse 1981; Tsuchiya 1979). To our knowlegde, however, there have been few reports on the changes in NCV related to lead content in the peripheral nerve tissue under lead poisoning (Hietanen et al. 1980).

In the present study, we have examined motor nerve conduction velocity (MCV) of the tail by a non-invasive method and lead content of the peripheral nerve in lead-exposed rats, and furthermore attempted to assess the relationship between these two parameters.

MATERIALS AND METHODS.

Fifty-three male albino rats (Wistar strain) were used in this experiment. The rats were housed in groups with food and tap water available ad lib. Cages were set in a room kept at 20-25°C and maintained on a 12-h light-dark cycle (lights on 7:00 A.M. to 7:00 P.M.). After 2-3 weeks of standardization to these conditions, the experiment was started at 9 weeks of age.

Either one or two ml of 1% (W/V) lead acetate ($Pb(AcO)_2$) solution was injected i.p. 6 or 8 times once a week; as a total, consequently, either 60 and 120 or 80 and 160 mg of lead acetate was injected per rat. Each control rat was injected with 1 ml of physiological saline. All rats were injected at about 10:30 A.M.

MCV was measured at the caudal nerve at the 3rd, 5th, 6th, 7th and 8th weeks after the 1st injection by the modification of Maehara et al. (1985) of the non-invasive method of Ono et al. (1979). The stimulus used was a square wave with 0.3 ms duration at 1 Hz and the intensity was a supramaximal voltage. The surface temperature of the tail was 35.5-37.1°C in the middle region.

After the MCV was measured on the 3rd day after the last injection of the 6th or the 8th week, blood samples were collected by decapitation. And then, about 2 cm from each of both sciatic nerves was cut and weighed. Lead contents in the blood and in the nerve sample were determined by a standard addition method using a Zeeman-effect atomic absorption spectrophotometer equipped with graphite furnace (Model 170-70, Hitachi Co.). A mixture of nitric acid and perchloric acid was used for the wet digestion of samples.

Statistical analysis was performed by Student's t-test or Aspin-Welch test. The effect on the changes of MCV was analyzed by a multiple regression analysis using body weight, and lead content in the nerve and the blood as explanatory variables (HITAC M-140H). The data of each variable was standardized to have a mean value=0 and a variance value=1.

RESULTS AND DISCUSSION.

As shown in Figure 1 , the mean body weights in the 10-mg exposed group (10-mg group) decreased slightly up to the 14th day and then increased gradually. The mean body weights of the 20-mg exposed group (20-mg group) showed the minimum levels on the 14th-21st day and then increased slightly up to the 52nd day; however, the value on the 52nd day was less than the pre-injection value.

Figure 2 shows the changes of MCV as means+SD. The MCV in both the control and the 10-mg group increased with age. At the 7th week, the MCV in the 10-mg group was significantly low compared with that in the control ($P < 0.01$), but not at the 8th week. When compared to the MCV of the control group, that of the 20-mg group was exceedingly low from the 5th week through the experimental period ($P < 0.01$) and at the 8th week was significantly low compared with that of the 10-mg group ($P < 0.05$).

Table 1 shows the lead content in the sciatic nerve and the blood. The lead content of the nerve in the 10-mg group was much higher than that in the control at the 6th week ($P < 0.01$) and the level at the 8th week

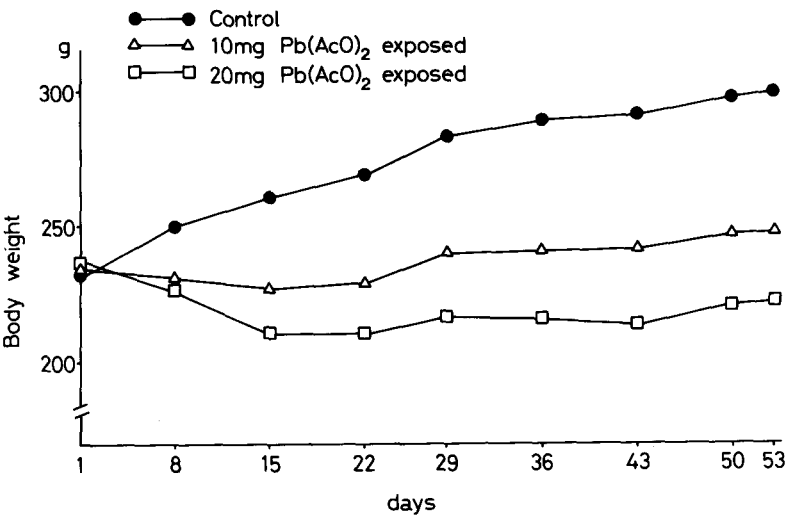

Figure 1. Changes in mean body weight in the control and lead exposed rats.

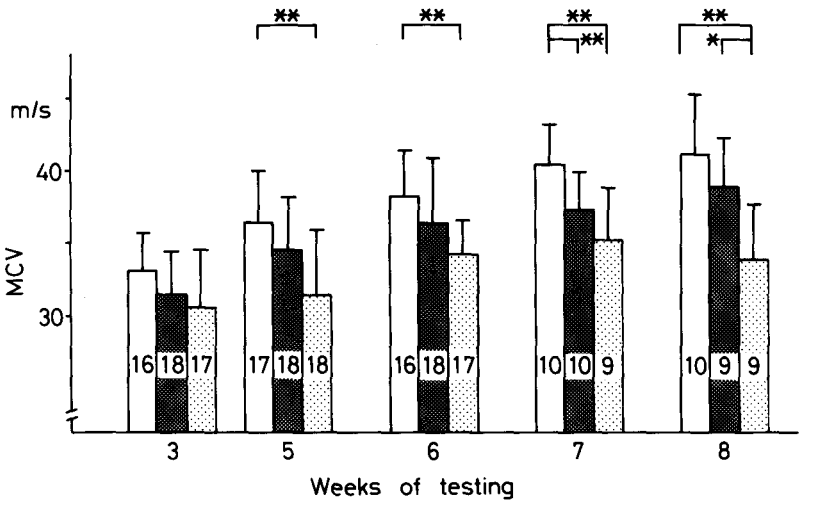

Figure 2. Changes of MCV of tail in the control and lead exposed rats. Columns and vertical bars represent means+SD. ▭ : control, ▩ : 10-mg $Pb(AcO)_2$ exposed group, ⁘ : 20-mg $Pb(AcO)_2$ exposed group. The number in each column shows samples size. *: $P < 0.05$, **: $P < 0.01$.

Table 1. Lead content in the sciatic nerve and the whole blood of the lead exposed rats.

		6th week		8th week	
Sciatic nerve (μg /100g wet weight)	Control	14.7±4.57 (7)	N.S.	11.2±6.20 (9)	**
	10mg-group	140 ±36.0 (8)	N.S.	148 ±34.5 (9)	**
	20mg-group	196 ±53.9 (7)	N.S.	278 ±89.8 (9)	
Whole blood (μg/ 100g wet weight)	Control	1.16±1.15 (7)	N.S.	1.01±0.40 (10)	**
	10mg-group	1200± 642 (8)	N.S.	888 ± 368 (8)	*
	20mg-group	1150± 374 (8)	N.S.	1790± 865 (9)	

All values represent mean ± SD. The number of samples is shown in parenthesis. N.S.: not significant, *: $P < 0.05$, **: $P < 0.01$.

remained almost unchanged. While, in the 20-mg group, the lead content in the nerve at the 6th week showed a significant increase even compared with that in the 10-mg group ($P < 0.05$) and at the 8th week increased twofold over the 10-mg group level ($P < 0.01$); however, there was no statistically significant difference in the content between the 6th and the 8th week. On the other hand, at the 6th week, lead content in the blood of the 10-mg group was almost the same as that in the 20-mg group. At the 8th week, blood lead content in the 20-mg group nearly doubled that in the 10-mg group ($P < 0.05$), there being no significant difference in the blood lead content between the 6th and the 8th week.

In the present study, the lead content in the nerves showed a high value even at the 6th week as well as the blood lead content. We thought that the present results corresponded to the following report (Windebank et al. 1980); lead began to accumulate significantly in the endoneurium of the sciatic nerve by 5 days and reached a maximum level by 34 days. These results support the hypothesis that a resistant barrier mechanism equivalent to the blood-brain barrier does not

Table 2. Multiple regression equations for the associations between MCV and the other variables in the control and lead exposed rats taken together.

week	Multiple regression equation	R
6th(n=22)	$Y= -0.51522^{*}X_1+ 0.00820\ X_2+ 0.10076\ X_3- 0.01232$	0.52890^{*}
8th(n=26)	$Y= -0.13480\ X_1+ 0.25217\ X_2- 0.18719\ X_3- 0.00443$	0.36395

Y=MCV; X_1= lead content in the sciatic nerve; X_2= body weight; X_3= lead content in the whole blood; R = multiple correlation coefficient.
*: $P < 0.05$.

exist in the peripheral nerves (Hietanen et al. 1980).

In previous study (Hietanen et al. 1980), the lead effects on MCV and the changes in lead content of the blood and the peripheral nerve have been demonstrated as follows: After a four-week lead exposure, the MCV decreased compared to the control, and one week later the decrease came statistically significant. At the 5th week, the lead content in the sciatic nerve increased markedly, whereas the blood lead content was at a steady state at the 4th to 5th weeks. And they concluded that MCV showed a direct relationship to the lead content of the sciatic nerve. In their experiment, however, the mean body weights in the lead exposed rabbit showed to be less than that in the control. The possibility cannot be dismissed that the changes in MCV in the early stage of lead poisoning may be induced not only by lead accumulation in the peripheral nerve but also by the deficiency of nutrition. Because in our present study, the 6th week results of simple correlation coefficient showed that MCV significantly correlated to lead content in the nerve and moreover lead content in the nerve significantly correlated to body weight ($P < 0.05$).

Therefore, in the present study, we conducted multiple regression analyses to solve the following problem: Which of the variables (lead content in the blood and in the nerve, and body weight) would most related with MCV? Table 2 shows the results of multiple regression analyses. On the 6th week result, lead content in the sciatic nerve explained a significant amount of the change in MCV ($P < 0.05$), while lead content in the blood and body weight were not significant predictors of the changes in MCV. However, at the 8th week, the variability associated with MCV was not explained by

the three variables.

Under the condition of lead administration accompanying body weight loss, our present results indicate that a lead accumulation in the peripheral nerve occurs from an early stage and consequently leads to reduction of motor nerve conduction velocity.

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