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Thallium in Whole Blood Samples from College Students in Taiwan

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The toxicity of thallium has been recognized since its discovery in 1861 and thus it has been used as a rodenticide. World Health Organization (WHO) suggested banning this practice owing to its extremely toxic in the early 1970's. However, the intoxication of thallium still occurs worldwide (Chandler et al 1990; Li and Aldism 1997; Malbrain et al 1985; Manzo and Sabbioni 1988; Zhou and Liu 1985). Thallium mainly affects the central nervous system and may cause visual disorders, hair loss and even death (Feldman and Levisohn 1993; Meggs et al. 1994). To mammals, thallium is more toxic than mercury, cadmium, lead, copper or zinc (Manzo and Sabbioni 1988; Mulkey and Oehem 1993; Wallwork et al 1985; Zhou and Liu 1985; Zitko 1975; Zitko et al 1975). Since World War II, great amounts of thallium compounds have used in military research and the manufacture of laser and acusto-optic equipments (Nriagu 1998), and nowadays, in the high-tech industries. Besides the release from industries, naturally occurring thallium may also pose high potential health risk in humans through the food chain (Xiao et al. 2004). Biomagnification of thallium in aquatic ecosystems has been reported higher than 10000-fold (Lin et al. 2001). In addition, the dominant species of thallium in the aquatic environment is found to be trivalent form (Lin and Nriagu 1999a,b) which is much more toxic than the monovalent one (Lan and Lin 2005; Ralph and Twiss 2002). This makes the health risk assessment based on monovalent thallium (Ewers 1988) suspicious.

Recently studies show that the major exposure to pollutants for humans is very close to us such as consumer products and building materials (Steinemann 2004). In addition, nearly 90% of our body burdens can be attributed to the indoor sources (Steinemann 2004). In Taiwan, the estimated population who burn incense sticks and candles every day is approximately four fifths of Taiwanese and continuing to increase owing to religious conversion (Lin 1997). Additionally, the proportion of families burning mosquito coils is approximately 45% in southern Taiwan (Yang et al. 1997). These activities were proven to be very important sources of trace metals in Taiwan (Lin and Shen 2005; Lin and Shen 2003; Lin et al. 2003). The estimated maximum concentration of thallium indoor can reach 8.3 ng/m^3 (Lin and Shen 2005; Lin and Shen 2003), which is about 38 times higher than that observed in the unpolluted ambient air (Struempler 1975). This estimation reveals that Taiwanese may be exposed to a great amount of

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thallium and deserve some attention in this matter. This study measures the thallium level in whole blood samples from college students, who represent the population without occupational exposure, as an alternative to estimate that of general population in Taiwan.

MATERIALS AND METHODS

A total of 47 students from a mid-size college of medical technology were randomly recruited in this study. The average age was 24.3 years old with a standard deviation of 4.6, ranging from 19 to 42. Twenty-three of them were male and others were female. No occupational exposure to thallium was expected to occur to these students. Among them, only five male students were smokers. The blood samples were collected by disposable polystyrene syringes with stainless needles and then stored in polypropylene vials at 4°C before analysis. Approximately one mL of blood sample was taken and digested with 10 mL of trace-metal free grade nitric acid (J.T. Baker) in microwave digestion bombs (CEM, MDS2000) whose operating conditions were controlled as follows: heating/digestion time: 25 minutes; pressure: 120psi. The digested samples were then diluted to 25 mL with Milli-Q water. Every digestion batch included one blank sample to estimate possible contamination from reagents and containers. All samples were analyzed three times with a Perkin-Elmer Elan 5000 Inductively Coupled Plasma – Mass Spectrometer (ICP-MS). The operation conditions were as follows: 1) Carrier gas (argon, 99.999%): 0.8 L/min; 2) Plasma gas (argon, 99.999%): 15 L/min; 3) Auxiliary gas (argon, 99.999%): 0.8 L/min; 4) Pump rate: 1.5 mL/min; 5) Power: 1055 KW. The method detection limit of Tl was 0.10 ng/mL.

RESULTS AND DISCUSSION

The overall average thallium concentration in blood samples was 1.90 ng/mL with a standard deviation of 1.67 ng/mL, ranging from 0 to 4.76 ng/mL (two samples below the detection limit and assumed to be 0). The average thallium level in female students was 1.46 ng/mL with a standard deviation of 1.35 ng/mL. For male students who did not smoke, the average thallium concentration was 2.62 ± 1.84 ng/mL. The average thallium concentration in blood of smokers was determined to be 1.44 ± 1.84 ng/mL. Despite the difference in thallium levels observed between male and female students ($p < 0.025$); no statistical significance exists between smokers and non-smokers. The distribution of thallium concentration was illustrated in Figure 1. Figure 1 indicates that there are two groups of blood thallium levels among these students can be characterized which may result in the difference observed because the proportions of these two groups among male and female students seem to be disparity. The factors responsible for this disparity remain unclearly and cannot be identified here because of limited data.

Only few data on thallium concentration in human blood are reported. For general population, the concentrations of thallium in blood range from 0.01

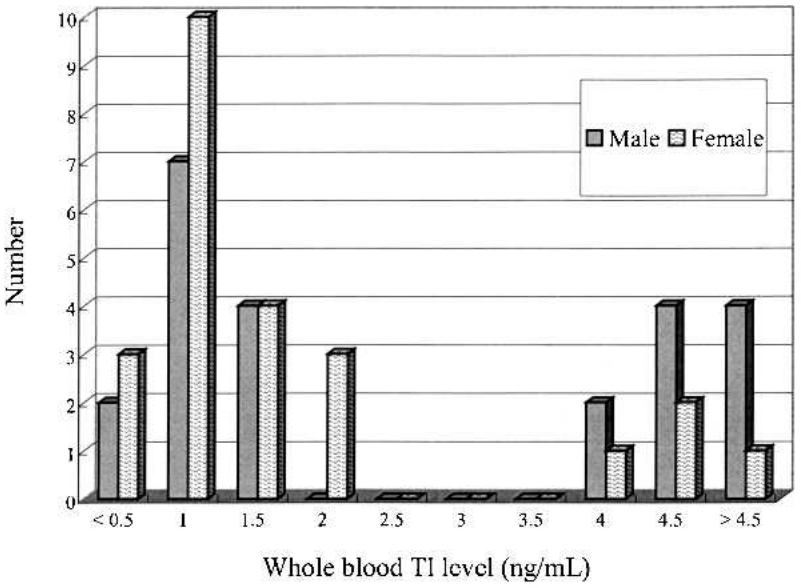

Figure 1. Distribution of vanadium concentration in blood samples

ng/mL to 1.1 ng/mL (Barany et al. 2002a; Barany et al. 2002b; Hamilton et al. 1994; Minola et al. 1990; White and Sabbioni 1998). The reference value of thallium in human blood was suggested to be 0.5 ng/mL (Hamilton et al. 1994). The blood thallium levels in patients intoxicated by thallium were higher than 50 ng/mL (Rios and Galvan-Arzate 1998) and could reach as high as 22.0 μg/mL (Zhou and Liu 1985).

Obviously, our results are about four times higher than the recommended reference value (0.5 ng/mL, Hamilton et al 1994). It indicates that Taiwanese may be exposed to more thallium from the environment, which may be a result of the practice of incense sticks, candles or mosquito coils every day at home. In addition, the consumption of fish may also be an important factor elevating the thallium levels in human blood for Taiwanese (Lin et al. 2005; Lin et al 2003).

Most hazard assessment of thallium to humans is based on the toxicity of monovalent thallium; however, the field studies show that trivalent thallium is the predominant species in an aerobic aquatic environment (Lin and Nriagu 1999a,b), and can be intensely bioaccumulated (Lin et al. 2001) and thus intaken by human beings through food chain (Lin et al. 2005). Since trivalent thallium may be more toxic than the monovalent one if it is ingested, the measurement of total thallium cannot well characterize its potential health impact. Thus, the results presented here clearly urge thoroughly exposure and health risk assessment for thallium in Taiwan.

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