Bull. Environ. Contam. Toxicol. (2004) 73:781–786

DOI: 10.1007/s00128-004-0495-9

Bulletin of Environmental Contamination and Toxicology

Whole Blood Vanadium in Taiwanese College Students

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Received: 30 May 2004/Accepted: 8 September 2004

Vanadium, a ubiquitous element, is more abundant than copper, iron and zinc in the earth's crust and averages at about 100 ppm in soil and sediment (Nriagu 1998). Vanadium can exist stably in the environment at several oxidation states such as +3, +4 and +5 etc. (Crans and Tracey 1998). Because of the strong complexes formed by vanadium(IV) and organic ligands, vanadium concentration in crude oil can reach up to percent level (Nriagu 1998). Regarding to the high level of vanadium found in crude oil, it is expected to be involved in the early photosynthesis. Vanadium is an essential element for some animals such as chickens and rats (Almedeida et al. 2001; Hopkins and Mohr 1971; Schwarts and Milne 1971); but there is no convincing evidence to show it is essential for human beings (Nechay et al. 1986; Nielsen 1985; Nielsen and Uthus 1990). Vanadium compounds are proved to have insulin-mimetic activity (Heyliger et al. 1985; Meyerovitch et al. 1987; Tolman et al. 1979) and thus expected to treat diabetes in the future (Brichard et al. 1991, Cohen et al. 1995; Shechter 1990). However, significant accumulation of vanadium in the kidneys owing to chronic vanadium treatment is observed (Mongold et al. 1990; Thompson and McNeill 1993). The possible intoxication of vanadium compounds, because of long-term administration for diabetes treatment, is therefore of crucial concern (Domingo 2000; Domingo 1996).

In addition, vanadium is recognized to be more toxic when inhaled than when ingested (Boyd and Kustin 1984). Exposure to great amount of airborne vanadium may occur in working environment. The vanadium level in air may reach as high as 500 mg/m^3 in boiler cleaning operations (WHO 1988). This value is much greater than the acute-duration inhalation minimal risk level (MRL) suggested by ATSDR (1992), which is 0.0002 mg/m^3. Ambient levels of vanadium range from 0.001 to 0.8 ng/m^3 in remote areas, from 0.2 to 75 ng/m^3 in rural areas, from 20 to 300 ng/m^3 in urban areas (Lowenthal et al. 2000; Mamane and Pirrone 1998; Soldi et al. 1996; Schroeder et al. 1987). In large cities, the maximum 24-h average could reach 1000 ng/m^3 (USEPA 1977). The most important anthropogenic source of vanadium in the atmosphere is combustion processes, in particular, fossil fuel burning (Nriagu and Pirrone 1998). Airborne vanadium is found to associate with cancers in male (Stock 1960). The vanadium level in lung tissue has been increasing since 1960's as a result of the

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deterioration of air quality (Fortoul et al. 2002).

In Taiwan, the degree of industrialization as well as the amount of automobile has been increasing tremendously in the last several decades. This phenomenon implies that ambient vanadium may exist in great amount in Taiwan; in particular, it does not attract much attention up to date in Taiwan. To our best knowledge, the reliable data regarding the influence of vanadium on humans as well as the environment in Taiwan may not exist yet. To assess the current body burden of vanadium may provide a good base for the future research such as health risk assessment due to vanadium exposure, the effect of chronic vanadium administration etc. This study aims to assess current vanadium level in blood in Taiwanese without occupational exposure to vanadium, and tries to determine vanadium in blood samples from college students as an alternative to estimate that of general population in Taiwan.

MATERIALS AND METHODS

A total of 52 students from a mid-size technical college were randomly recruited in this study. The average age was 24.2 years old with a standard deviation of 4.5, ranging from 19 to 42. Twenty-six of them were male and others were female. No occupational exposure to vanadium was expected to occur to these students. Among them, only five male students were smokers. The blood samples were collected by disposal polystyrene syringes with steel needles and then stored in polypropylene vials at 4 °C analyzed. Approximately one mL of blood sample was taken and digested with 10 mL of trace-metal free grade nitric acid 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 minimize possible contamination from reagents and containers. All samples were analyzed three times by using 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 instrument detection limit of vanadium was 7.8 ng/L.

RESULTS AND DISCUSSION

The overall average vanadium concentration in blood samples was 0.42 ng/mL with a standard deviation of 0.24 ng/mL, ranging from 0.01 to 1.20 ng/mL. The distribution of vanadium concentration was illustrated in Figure 1. The average vanadium level in female students was 0.37 ng/mL with a standard deviation of 0.24 ng/mL. For male students who did not smoke, the average vanadium concentration was 0.44 ± 0.32 ng/mL. The average vanadium concentration in blood of smokers was determined to be 0.47 ± 0.32 ng/mL. Despite the difference in vanadium levels observed between male and female students, no statistical significance exists between smokers and non-smokers.

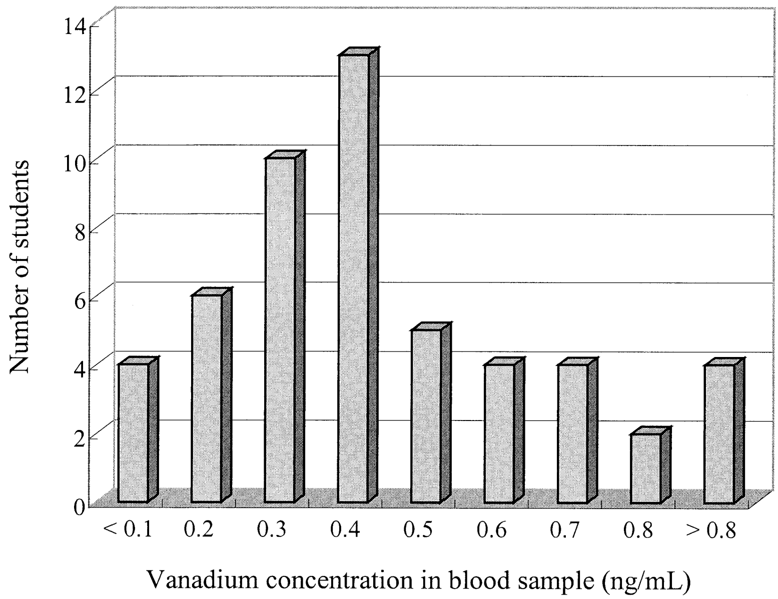

Figure 1. Distribution of vanadium concentration in blood samples

Only few data on vanadium concentration in human blood are reported. For general population, the concentrations of vanadium in blood range from 0.032 ng/mL to 0.095 ng/mL (Byrne and Kucera 1992; Lener et al. 1998; Kucera et al. 1998; Kucera and Sabbioni 1998; Kucera 1992; Kuera et al. 1991; Sabbioni et al 1998). The concentration of vanadium in blood of the residences affected by industrial source may be elevated to 0.10 ± 0.07 ng/mL (Lener et al. 1998). The value of occupational exposed people may reach to 33.2 ± 69.2 ng/mL, ranging from 3.10 ng/mL to 217 ng/mL (Kucera et al. 1998).

Obviously, our results are about ten times higher than others'. It indicates that Taiwanese may be exposed to more vanadium from the environment. In spite of the decreased emission of vanadium into the atmosphere in the developed countries in the last two decades; in contrast, the vanadium emission in Asia has increased more than 60% in the last twenty years (Nriagu and Pirrone 1998). This phenomenon clearly implies that the inhalation of airborne vanadium may be critical in the elevation of blood vanadium level in Taiwanese. The reported ambient vanadium levels in urban areas may support this argument; for example, the reported concentrations range from 0.5 to 1.9 ng/m^3 in Chicago, and from 210 to 350 ng/m^3 in Beijing (Mamane and Pirrone 1998). Unfortunately, there is no data available in Taiwan yet.

Children exposed to ambient vanadium may have lower values of red blood cell counts, hemoglobin content, and hematocrit (Lener et al. 1998). It is noteworthy that the vanadium concentration in blood samples from the medium exposed group is 0.10 ± 0.07 ng/mL (no data available for the exposed group) and the vanadium levels in fingernails are similar between the medium exposed (186 ± 38 μg/kg) and exposed (186 ± 38 μg/kg) groups in their study, compared with our results, which is only one fourth. In addition to the inhalation of airborne vanadium, people may intake more vanadium from food or water (WHO 1988). Unfortunately, there is no data available in Taiwan, either. Hence, this paper clearly calls for a detailed integrity assessment of the exposure of vanadium as well as the health effect and risk due to the exposure in Taiwan.

Acknowledgments. We acknowledge the partial financial support for this work provided by Taiwan National Science Council (Grant #: NSC90-2113-M-264-002; NSC91-2113-M-264-002).

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