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Interrelationship between lead and cadmium contents in hair and internal organs of female buffaloes

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Abstract

The goal of the present study was to investigate the correlations between lead and cadmium contents in hair and internal organs of female buffaloes (8-11 years old). Lead and cadmium concentrations were determined in whole blood, hair, liver, kidney, muscle and bone tissues by means of Atomic Absorption Spectrophotometry. The results revealed significant positive correlations between concentrations of lead in: hair and blood, liver and kidney, liver and muscle, liver and bone, kidney and bone and muscle and bone, On the other hand, there were significant positive correlations between concentrations of cadmium in: hair and muscle, hair and bone, blood and liver, blood and kidney, blood and muscle, liver and kidney and kidney and muscle. The current study demonstrated significant positive correlations between lead and cadmium concentrations in hair and internal organs.

INTRODUCTION

Pollution of the environment with heavy metals is a serious problem, which is recognized in most countries of the world (Abou-Arab, 2001). Industrial and agricultural processes have resulted in the release of many toxic metals into the environment, although high concentrations can also occur naturally, cadmium and lead are the elements that causing the most concern. This because they are readily transferred through food chains and can pose a potential health risk to human and animals (Friberg et al., 1979).

Various specimens, such as blood (Vanhoe et al., 1989; Melton et al., 1990 and Forrer et al., 2001) or hair (Feng et al., 1997 and Puchyr et al., 1998) may be used to assess element status in man and animals. Absorbed elements are incorporated into hair and can be used as an indicator for exposure. Hair samples were easy to collect, transport and store which, makes analysis easier (Airey, 1983). The level of elements in hair reflect their levels in the body medium from which it was formed and provides a historical record of elements assimilated from the environment (Phelps et al., 1980). A vast amount of research effort has been expended to explore the value of hair-element analysis and to screen for the correlations between toxic and trace elements in hair and tissues, little work has done to assess the correlations between lead and cadmium concentrations in hair and tissues of female buffaloes, which is the goal of the present study.

MATERIALS AND METHODS

ANIMALS

A total of 20 female buffaloes (8-11 years old) were subjected to study. These animals were slaughtered in slaughterhouses belong to Assiut governorate (Assiut, Egypt). Blood samples (5 ml) were collected from the jugular vein in metal free labeled and capped tubes containing 1% heparin as anticoagulant. Hair samples (about 5g) were taken from the upper part of the tail region using stainless steel scissors, samples of hair were washed with tap water several times and soaked for 12 hours to remove exogenous contamination, and then defattened with ether/acetone mixture for ten minutes. After that, samples rewashed with bidistilled water for about 10 minutes with continuous stirring, then dried and kept for chemical analysis (Ryabukhin, 1978). Samples of at least 10g specimens were obtained from: the caudate process of the liver, kidney cortex, sacrocaudalis muscle and coccygeal vertebrae. All samples were packed in clean, labeled plastic bags and then kept in deep freeze (-20 ºC) for chemical analysis.

ANALYTICAL METHODS

Blood (Zilva, 1973), Hair (Harrison et al., 1969), bone and tissue (Koirtyohann et al., 1982) specimens were digested according to methods mentioned in previous studies. All chemicals used were of analytical-reagent grade and the highest purity available. Double distilled deionized water

HPLC-grade, were used throughout. Glass vessels were cleaned by soaking in acidified solutions of nitric acid and rinsed several times with high-purity deionized water. Nitric acid (approx. 65%, Merck) and perchloric acid (approx. 70%, Merck KgaA Darmstadt, Germany, Suprapur) were used. Metal levels were calculated on the basis of similarly prepared Merck standards. Lead and cadmium concentrations were determined in digested samples using Atomic Absorption Spectrophotometry (Atomic absorption 906, GBC, Australia).

STATISTICAL ANALYSIS

All statistical analyses were performed using SPSS statistical software (SPSS for Windows, Version 14.0, CA, USA) by means of correlation coefficient and linear regression analysis for the cadmium and lead concentrations in tissues

RESULTS

The results revealed significant positive correlations between concentrations of lead in: hair and blood ($r = 0.676$, $p<0.05$), liver and kidney ($r = 0.718$, $p<0.01$), liver and muscle ($r = 0.545$, $p<0.05$), liver and bone ($r = 0.654$, $p<0.05$), kidney and bone ($r = 0.667$, $p<0.05$) and muscle and bone ($r = 0.563$, $p<0.05$). On the other hand, there were significant positive correlations between concentrations of cadmium in: hair and muscle ($r = 0.662$, $p<0.05$), hair and bone ($r = 0.708$, $p<0.05$), blood and liver ($r = 0.861$, $p<0.01$), blood and kidney ($r = 0.889$, $p<0.01$), blood and muscle ($r= 0.716$, $p<0.01$), liver and kidney ($r= 0.874$, $p<0.01$) and kidney and muscle ($r= 0.650$, $p<0.05$). Results are summarized in tables 1 and 2.

Figure 1

Table 1: Correlations of lead (ppm) among hair, blood, muscle, kidney and bone of female buffaloes

	Hair	Blood	Liver	Kidney	Muscle	Bone
Hair	1.000	**.676***	-.037	.247	.244	.198
Blood		1.000	-.113	.115	.228	.464
Liver			1.000	**.718****	**.545***	**.654***
Kidney				1.000	.377	**.667***
Muscle					1.000	**.563***
Bone						1.000

* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

Figure 2

Table 2: Correlations of cadmium (ppm) among hair, blood, muscle, kidney and bone of female buffaloes

	Hair	Blood	Liver	Kidney	Muscle	Bone
Hair	1.000	.245	.087	.349	**.622***	**.708***
Blood		1.000	**.861****	**.889****	**.716****	.225
Liver			1.000	**.874****	.376	.087
Kidney				1.000	**.650***	.071
Muscle					1.000	.064
Bone						1.000

* Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

DISCUSSION

Toxic metal accumulation and the resultant interactions between toxic elements have been investigated in cattle and other farm animals from polluted areas (Koh and Judson, 1986; Langlands et al. 1988 and Telisman et al., 1990) and in experimental studies (Reddy et al. 1987; Wentink et al. 1988; Smith et al. 1991a, 1991b). These researches were conducted to screen for concentrations of toxic metals in bovine (Wright et al., 1976; Kreuzer et al., 1979; Logner et al. 1984; Vaessen and Ellen, 1985; Kofer et al., 1986; Jorhem et al., 1991; Niemi et al., 1991; Falandysz, 1993; Doganoc, 1996; Abou-Arab, 2001 and Abdou et al., 2004) and to investigate the interactions between essential and trace elements in the same organ (Telisman et al., 1990 and Lo´pez Alonso et al., 2002). In the present study, the correlations between lead and cadmium concentrations were investigated in hair and tissues of female buffaloes, which revealed significant positive correlations between lead and cadmium contents in hair and internal organs. The significant correlations between hair and blood lead concentrations were in agreement with that reported by same study on human (Kopito et al., 1967; Barltrop et al., 1975; Grandjean, 1984; Chatt and Katz, 1988; Foo et al., 1993; Chlopicka et al., 1995 and Pietrzyk et al., 1995). It is known that lead in blood distributed to soft and hard tissues including hair (Goyer and Mushak, 1977), also about 16 % of lead in blood is excreted in hair (Schramel and Ovcar-Pavlu, 1988); these may explain the positive correlations between lead concentrations in hair and blood.

There is some evidence that with prolonged exposures, less lead enters bone and more binds to proteins, possibly metallothionein, such binding tend to increase the half-life of lead in the blood (Church et al., 1993). Lead in bone may contribute as much as 50% of blood lead, so that it may be a significant source of internal exposure to lead (Silbergeld et al., 1988). In addition, measurement of lead in bone has been adopted as an indicator of cumulative lead exposure, and as a source of body lead burden that can be mobilized into the circulation (Links et al, 2001), which may explain the significant positive correlations between bone lead and its concentration in muscle ($r = 0.563$, $p<0.05$), liver ($r = 0.654$, $p<0.05$) and kidney ($r = 0.667$, $p<0.05$).

There are different opinions on the usefulness of hair as an indicator of environmental or occupational exposure to cadmium (Taylor, 1986). It was reported that hair was not a good indicator for exposure to cadmium (Matsubara and Machida, 1985). Moreover, no correlations were found between the content of cadmium in hair and different organs of rat Brancato, et al. (1976) and Kollmer (1982). It was established that the concentration of cadmium in hair correlates well with its whole body retention (Nordberg and Nishiyama, 1972) Results of the present study revealed significant positive associations between hair cadmium concentration and its concentration in muscle ($r = 0.662$, $p<0.05$) and bone ($r = 0.708$, $p<0.05$). Reportedly, cadmium in blood distributes firstly to the liver and then to the kidneys, which is the target organ for cadmium (Friberg et al., 1974 and Sharma et al., 1982), which may explain the significant positive correlations between blood cadmium concentration and its concentration in liver and kidney. In conclusions, significant positive correlations between lead and cadmium concentrations of hair and internal organs were established in the present study. In addition, hair can be used as indicator for concentration of lead in blood, and as indicator for cadmium concentrations in muscle and bone.

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