Bull Environ Contam Toxicol (1984) 32:525–532

Bulletin of Environmental Contamination and Toxicology

Elevation of Cadmium, Lead, and Zinc in the Hair of Adult Black Female Hypertensives

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The southern portion of the United States has the highest mortality due to cardiovascular disease of any region of the country. The prevalence of hypertension in the South is also higher. In Mississippi, 37% and 16% of adult blacks and whites respectively, are estimated to be hypertensive by the Mississippi Affiliate of the American Heart Association.

Dietary intake of sodium, an overweight condition, and genetic factors may contribute to the problem. The role of trace elements in producing hypertension was first recognized by Schroeder (1965, 1967). Rats became hypertensive by ingesting cadmium in drinking water or by intraperitoneal injection of the elements. The addition of dietary zinc could block the cadmium induced hypertension, suggesting a complex interaction among elements.

Trace elements may be involved in the etiologies of other circulatory diseases as well. For example, Klevay (1975) has suggested that a copper-zinc imbalance may lead to hypercholesterolemia and ischemic heart disease while the World Health Organization (1974) has reported increased copper concentration in the heart tissue of coronary victims. Epidemiological studies (Schroeder 1960 and 1966; Sharrett and Feinleib 1975; Perry and Perry 1974) have revealed an inverse relationship between water hardness and the prevalence of heart disease. Borgman et al. (1982) demonstrated a positive correlation between hair copper, cadmium, lead, and chromium concentrations of adolescents and the heart disease rate of their respective home counties.

The objective of the present study was to explore the relationship of selected trace elements with tensive status using hair as a biopsy material. The study examined the differences in hair elemental concentrations between adult black female hypertensives and normotensives from low socioeconomic backgrounds.

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METHODS AND MATERIALS

The twenty adult black females who participated were patients of a general practitioner in Starkville, Mississippi. Subjects classified as having hypertension had been receiving anti-hypertensive medications for several years. All subjects came from low socioeconomic levels and were on some type of government subsistence. Fourteen adult black female normotensives were recruited by the same practitioner and had similar mean age and age range as the hypertensives. All participants signed an informed consent agreement as approved by the University's Institutional Review Board for the Protection of Human Subjects.

A nurse was instructed to record medications currently prescribed and other diagnosed diseases for each subject. Age, weight in kilograms, and height in centimeters were also recorded and a weight:height index was computed for each subject. Hypertensives who participated had their blood pressures under control through prescribed medications. Most of the hypertensives studied also had other diseases such as diabetes, osteoporosis, and other cardiovascular conditions. A summary of disease condition and drug therapy for these subjects is given in Table 1. Hair was sampled from each subject as described below.

Hair was cut with stainless steel scissors close to the scalp from the occipital area of the head. Only the 2 cm closest to the scalp was used. The procedure for washing was a modification of a published method (McKenzie 1978). Hair samples were placed on moistened Whatman filter paper in a Buchner funnel. Fifty milliliters of deionized-distilled water was passed over the hair and drained. A 60 ml 0.1 M EDTA (disodium ethylenediamine tetraacetate) solution were passed over the hair, followed by two rinsings with 50 ml portions of deionized-distilled water. Suction was applied to aid in the removal of moisture. Hair samples were transferred to nitric acid washed glass beakers, covered with watch glasses, and placed in a vacuum oven for 48 hr at 56^{o}C, 30 psi. After drying, hair samples were weighed and wet ashed in 6 ml of a solution of nitric and perchloric acids. Wet ashing continued until white fumes evolved. Samples were diluted up to 10 ml in nitric acid washed volumetric flasks with deionized-distilled water.

Mineral standards were prepared daily from Fisher Certified Standards (Fairlawn, NJ). Standards were acidified to match samples in terms of matrix. At least 98% reproducibility was achieved from day to day in terms of absorbance values with freshly prepared standards.

Copper and zinc were analyzed by using a Perkin-Elmer flame atomic absorption spectrophotometer (Model 2380, Norwalk, CT). Cadmium and lead content were determined with a Perkin-Elmer graphite furnace (HGA-400, Norwalk, CT). Operating parameters were as suggested by the manufacturer (Perkin-Elmer Corp. 1976). Samples were read

Table 1. Disease, drug treatment, and blood pressure of hypertensive subjects at time of study.

Subject	Blood Pressure	Anti-Hypertensive Treatment [1]	Other Diseases				
			Diabetes	Circulatory	Skeletal	Cancer	Miscellaneous
1	140/90	D, H	X	X			
2	130/92	A, HCZD	X				
3	142/90	HCZD	X				X
4	140/90	APR, R	X	X	X		
5	160/96	D, R	X	X			
6	130/80	R, HCZD	X				
7	130/84	D	X		X	X	
8	120/80	HCZD	X				
9	150/90	D, H, L	X	X			
10	142/80	A, HCZD					
11	130/80	A, HD					

Table 1 (Continued)

Subject	Blood Pressure	Anti-Hypertensive Treatment [1]	Other Diseases				
			Diabetes	Circulatory	Skeletal	Cancer	Miscellaneous
12	150/100	D, H					
13	150/90	HCZD, R					
14	116/88	HD	X				
15	130/80	HCZD, R				X	X
16	140/80	A, R				X	
17	134/90	HCZD, R		X	X		X
18	130/88	D			X		
19	140/70	A, HCZD	X	X			
20	155/100	HCZD					

[1] Abbreviations indicate the following pharmocological anti-hypertensive agents: A, Apresoline; APR, Apresazide; D, Dyazide; H, Hydralazine; HCZD, Hydrochlorothiazide; HD, Hydropres; L, Lasix; R, Reserpine.

in duplicate and when different readings were obtained, additional readings were taken until reliability was achieved. Hair element concentrations were expressed as parts per million (ppm) or µg/g dry weight. Hair Zn:Cd and Cu:Zn ratios were calculated for each subject.

Differences in age, weight:height ratio, and hair element concentrations between adult black hypertensives and normotensives were determined by Student's t-test (Steel and Torrie 1980).

RESULTS AND DISCUSSION

The mean age of the subjects sampled was not significantly different ($p>0.05$) between hypertensives and normotensives (Table 2). The age range was similar for both groups. Likewise, no significant difference in weight:height index was found between the two groups. Hypertensives had significantly greater concentrations of hair cadmium ($p\leq0.05$), lead ($p\leq0.05$), and zinc ($p\leq0.01$) concentrations than the normotensive group. Hair copper concentrations were not statistically different ($p>0.05$) between the two groups. Hypertensives had significantly ($p\leq0.05$) lower Zn:Cd and Cu:Zn ratios than normotensives.

Table 2. Age, weight:height index, and hair element concentrations among subjects.

Item	Hypertensives (N=20) Mean (±S.E.)	Normotensives (N=14) Mean (±S.E.)	P
Age (yr)	53.2 ± 2.6	45.4 ± 3.3	NS
Weight:Height	.488 ± .021	.488 ± .031	NS
Cadmium (ppm)	7.92 ± 1.77	1.54 ± .43	0.05
Lead (ppm)	54 ± 12	22 ± 6	0.05
Copper (ppm)	21 ± 3	40 ± 13	NS
Zinc (ppm)	704 ± 105	251 ± 48	0.01
Zn:Cd	137 ± 22	291 ± 56	0.05
Cu:Zn	.052 ± .020	.195 ± .078	0.05

Most hypertensive subjects were taking more than one type of antihypertensive drug and all had their blood pressure reasonably well controlled (Table 1). Eleven out of the 20 hypertensive subjects were also diabetics. Normotensives were comparatively healthy, and at the time of the study, were visiting the physician's office for minor ailments.

The high elevation of cadmium and zinc in the hypertensives is of interest. Cadmium has long been known to cause hypertension in animals and zinc can block these effects (Schroeder 1967). Schroeder (1965) demonstrated greater renal cadmium concentrations and lower Zn:Cd ratios in the subjects dying from hypertensive complications compared to subjects dying from accidents. It would appear that a higher dietary zinc would be beneficial in preventing the effects of cadmium upon blood pressure. An inspection of the data revealed that normotensives had higher Zn:Cd ratios than hypertensives which suggests a protective role for zinc.

The hair zinc levels in the hypertensives was two to three times the reported values (McKenzie 1978). The hair cadmium levels in the hypertensives were higher than values reported elsewhere (Jenkins 1979). Cadmium is oftened inhaled through cigarette smoke, is used in various industries, and is found in certain phosphate fertilizers and paint pigments. The area in which the subjects lived is relatively non-industrialized. Since both cadmium and zinc were elevated in hypertensives it is plausible that water from a type of galvanized plumbing found in older homes was a source (Ensminger et al. 1983). This study did not investigate this possibility. Black polyethylene pipes, which are used in newer homes in the area, may also contribute to cadmium in the water supply (Goodhart and Shils 1980). Future research should investigate the water consumed, type of plumbing present in their homes, and containers food and water are held in. Cigarette smoking needs to be further investigated in this population.

Hair lead levels were also elevated in hypertensives. Lead content of hair is often variable and to a large extent reflects lead in the immediate environment (Jenkins 1979). Older plumbing, home distilled spirits, and automobile exhaust can contribute to the problem. Beevers et al. (1976) has reported higher blood lead concentrations in Scottish male hypertensives compared to their normotensive counterparts. They suggested that lead pipes and water stored in lead-lined tanks was a probable source of the element.

Copper content of hair did not differ but Cu:Zn ratios did. This is not surprising since hypertensives had much more hair Zn than normotensives and there was a trend toward greater hair Cu concentrations in normotensive subjects. Klevay (1975) has long postulated that a dietary or metabolic imbalance of copper and zinc can lead to ischemic heart disease. Since hypertension is a confirmed risk factor for ischemic heart disease, a copper-zinc imbalance may be associated with high blood pressure. In young adults, blood pressure has been noted to have a negative association with hair Cu and hair Cu:Zn ratios (Medeiros et al. 1983).

Hambidge (1982) has recently questioned the interpretation of results from hair analyses. As he points out, many entrepeneurs have appeared who use trace elements in hair analyses for diagnostic purposes. Many hair elements, such as sodium, potassium, calcium, and magnesium, may not reflect diet or metabolic status. The lack of research data does not permit their use for diagnosing possible illnesses. Hair cadmium, lead, copper, and zinc are the elements which have received the greatest amount of attention. For these elements, hair probably reflects trace element status to some extent. More research utilizing animals and diseased individuals is needed to establish hair analyses as a valid method of diagnosis.

Results from the present study suggest that adult black female hypertensives had a greater exposure or were able to absorb more cadmium, lead, and zinc than normotensives. These data indicated that further research is warranted on the effects of trace elements upon human hypertension.

Acknowledgements. The authors wish to thank Dr. L. Howell for recruiting the hypertensive patients, and L. Murray, RN for her assistance in this study. This study was supported by funds from the Mississippi Agricultural and Forestry Experiment Station, Project No. MIS-4027.

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Received September 20, 1983; accepted October 5, 1983