ENVIRONMENTAL RESEARCH 12, 355–357 (1976)

Nickel Levels in Hair and Nickel Ingestion in Guinea Pigs[1]

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Received January 28, 1976

Hair samples from control guinea pigs and from animals receiving 2.5 μg Ni/ml in drinking water for 4 months were analyzed for nickel by atomic absorption spectrometry. No significant differences in nickel contents were observed. These findings are interpreted as an indication that hair is not a tissue for valid biopsy in the assessment of nickel ingestion.

INTRODUCTION

Hair has long been considered as a minor excretory organ for trace elements. Because of the ease with which samples can be collected, hair has become increasingly popular as a tissue for biopsy in assessment of nutritional status (Bowen, 1972; Petering, Yeager, and Witherup, 1973), for the determination of toxic element exposure (Nord, Kadaba, and Sorenson, 1973; Sorenson, Melby, Nord, and Petering, 1973) and for medical diagnosis (Briggs, Briggs, and Wakatama, 1972; Yurachek, Clemena, and Harrison, 1969).

Correlations between mercury ingestion and mercury levels in hair have been established (Giovanoli-Jakubczak and Berg, 1974), and lead levels in hair have been related to chronic lead poisoning (Kopito, Byers, and Shwackman, 1967). In the case of nickel, however, there is some controversy concerning the correlation between nickel levels in hair and nickel exposure. Eads and Lambdin (1973) reported that nickel is uniformly distributed along the hair strand, but Valcovic, Rendic, and Phillips (1975) report that the nickel concentration increases along the hair strand. The latter interpret their findings as an indication of environmental exposure to nickel, while the former suggest that nickel levels in hair do not reflect nickel levels in other tissues.

Recently Baer and Fisher (1976) reported that unsuspected ingestion of nickel may be causing unexplained flare-ups of contact dermatitis in nickel sensitive individuals. Unsuspected ingestion of nickel can occur in various occupational releated exposures. Can hair be used as an indicator system to determine nickel ingestion, albeit nickel sensitivity is not reflected in the nickel contents of hair (Katz, Bowen, Comaish, and Samitz, 1975)?

MATERIALS AND METHODS

The guinea pig was used as an experimental vehicle to determine if nickel

[1] This research was supported under Grant HO 00303, National Institute for Occupational Safety and Health, Public Health Service, Department of Health, Education and Welfare.

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ingestion results in increased nickel levels in the hair. Twelve male and 12 female albino guinea pigs (Hartley, 300–400 g) were divided into four groups: six male controls, six female controls, six males exposed to nickel in drinking water, and six females exposed to nickel in drinking water. The control animals received tap water while the exposed animals were given tap water containing 2.5 μg Ni/ml. All animals were housed and fed under identical conditions for 4 months. During that time, two female guinea pigs from the control group died. At the end of the 4-month exposure period, the remaining animals were shaved on the backs and sides with an aluminum-headed, electric clipper. The hair from each animals was stored in separate plastic bags.

Samples of guinea pig hair (5–10 g) were weighed into separate Erlenmeyer flasks which were previously cleaned with nitric acid and rinsed with deionized water. The flasks containing the hair samples as well as empty flasks serving as blanks were treated with 25 ml of concentrated nitric acid and allowed to stand overnight. After this time, the contents were heated to boiling on an electric hot plate. Successive 25 ml portions of concentrated nitric acid were added to each flask, with care being taken that all flasks—those containing the hair samples and those containing the blanks—were treated with the same total amount of acid. The boiling was continued until digestion was complete. The contents of each flask were then quantitatively transferred to 50 ml volumetric flasks and brought to volume with deionized water. The sample from one exposed male guinea pig was lost during the digestion process.

The nickel levels were measured by atomic absorption spectrometry using a Perkin-Elmer model 360 instrument. Operating in the concentration mode in accord with the manufacturer's instructions, linearity between meter reading and nickel concentration was established over the 0.4 to 4.0 μg Ni/ml range with nickel standards in nitric acid.

RESULTS

The results of these measurements are summarized in Table 1.

DISCUSSION

The data in the table reflect no significant differences among any of the four

TABLE 1
NICKEL LEVELS IN HAIR FROM EXPOSED AND CONTROL GUINEA PIGS

	Control	Exposed
Males		
Mean	4.59 μg Ni/g	3.35 μg Ni/g
SD	2.26	1.68
Range	1.65–7.46	1.16–5.59
Number	6	5
Females		
Mean	4.20 μg Ni/g	3.99 μg Ni/g
SD	2.93	2.33
Range	1.24–8.24	1.48–7.38
Number	4	6

groups. Consequently, we cannot support the idea that hair is one of the physiological routes by which ingested nickel is excreted from the body in guinea pigs. It is, of course, possible that the levels of exposure were not sufficiently high to produce a state of chronic systemic nickel intoxication. The 2.5 μg Ni/ml exposure dosage was chosen because it is 50 times the maximum allowable concentration for most toxic elements in potable water (Potable Water Standards, 1970), but less than 0.05 of the LD_{50} for the guinea pig (Nickel, 1975). Without data on the hair cycle of the guinea pig, it cannot be firmly established that ingested nickel would appear in the hair within the 4 month exposure period. In the case of the rat and the rabbit, however, the hair cycles are reported to be 31 and 34 days, respectively (Moretti, Cipriana, Rebora, Rampini, and Crovato, 1967; Rony, Cohen, and Schaffner, 1953). Assuming that 4 months was sufficient to establish equilibrium between ingested nickel and the hair, and that the dose of 2.5 μg Ni/ml was sufficiently high to be a significant exposure, the nickel levels of hair do not reflect nickel exposure in the guinea pig. Schroeder and Nason (1969) have reached a similar conclusion for humans on the basis of the failure of nickel to accumulate in the hair with age. It seems reasonable to assume that measurement of nickel in hair cannot be used as an indicator system relative to nickel ingestion.

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