Hair analysis — a critical review

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In 1982 the College of Physicians and Surgeons of Ontario declared in an interim report that "present knowledge with respect to hair analysis does not justify its use in the detection of any nutritional deficiency or excess, with the possible exception of zinc deficiency. . . . The use of commercial hair analysis by physicians in clinical practice is, in the present state of knowledge, a procedure that is imprecise, unnecessary and probably wasteful."[1] Yet some chiropractors, so-called nutrition consultants, "fringe" dentists and practitioners of orthomolecular medicine use hair analysis as a diagnostic aid; for example, an advertisement in a popular health magazine recommends using hair analysis to detect an improper "nutritional balance of essential minerals" and "heavy metal accumulations in your body".[2]

The information provided by commercial laboratories is under neither scientific scrutiny nor government regulatory controls; therefore, the information may be inaccurate, misleading and even detrimental to the patient's health. Indeed, the misuse of hair analysis has been so blatant and extensive that scientists are often reluctant to do research in the area.[3]

Nevertheless, the procedure has major potential advantages over more invasive techniques for detecting trace elements in the body: hair can be collected easily and painlessly, it is easy to transport, it requires no special techniques for storage, and, unlike blood, serum and urine, it provides a historical perspective about concentrations of trace elements in the body — once deposited in the hair root and thence in the hair shaft the elements are bound permanently. In addition, trace elements are often more concentrated in the hair than in blood, serum or urine. Finally, hair analysis provides information about intracellular accumulations of elements, whereas analyses of blood or serum reveal only the extracellular concentrations of the substances at the time the sample was taken, and urinalysis identifies only extracellular substances that have been excreted.[4]

In spite of the potential worth of hair analysis as a diagnostic tool, its regular use in clinical practice is impeded by major problems in choosing the sample of hair to be analysed, preventing contamination of the sample, preparing the sample for analysis, analysing the sample and interpreting the results.

Choosing the hair sample

Cornelis[6] found that the concentration of antimony in hair samples taken from 16 sites on the scalp of one subject varied dramatically: the standard deviation of the measurements was 76%. In addition, the analysis may be affected by the length of the hair; for example, the concentrations of copper and zinc in the hair shaft have been found to increase with the distance from the hair root.[6] Thus, several samples of hair should be taken from different sites at the nape of the neck.

Preventing contamination

Quartz or plastic cutting instruments prevent metallic contamination of the hair sample while it is being taken, but previous contamination from environmental substances may be difficult or impossible to avoid. Hair shampoos, cold-wave lotions, hair sprays, bleaches and dyes can affect the results of analysis.[7,8]

Other environmental contaminants may or may not be desirable, depending on the purpose of the analysis. Pollutants that collect on the hair may be valuable clues in environmental studies; for example, in individuals living near lead smelters lead may be found in increasing amounts on the hair shaft from the root to the tip of the hair.[9] However, if the intent is to measure elements deposited within the hair shaft the hair must be washed to remove dust, grease and other contaminants.[10]

Many washing materials have been tried (e.g., acetone, ethylenediaminetetra-acetic acid, ionic and nonionic detergents, acids and water), but even when standardized techniques, such as that of the International Atomic Energy Agency,[11] are used the concentrations of trace elements in hair taken from the scalp are greater than those in hair taken from an unexposed area, such as the pubis.[12] Buckley and Dreosti[13] deliberately contaminated hair with labelled zinc and then used various standard washing procedures to determine their effectiveness. None of the methods removed all of the labelled zinc on the outside of the hair, but all of them removed some of the zinc deposited within the hair shaft. A washing procedure that removes the external

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material yet leaves the internal chemical composition of the hair intact has yet to be found.[14] Furthermore, Assarian and Oberleas[15] stated that "the results obtained by different laboratories utilizing different washing procedures should not be compared".

The only, albeit unproven and often impractical, alternative to washing is Chittleborough and Steel's "holistic no-wash approach",[16] which involves the use of only very short hair (e.g., new beard growth in men) to reduce the possibility of contamination from external pollutants.

Analysing the sample

Experienced analysts are well aware of the difficulties in measuring only two or three trace elements in a single hair sample because of interference between the elements, but many commercial laboratories claim to be able to detect and measure more than 20 elements in a single sample of hair using new elaborate and expensive, but largely untested, atomic emission spectrophotometers.[17] Also, some "nutrition laboratories" provide computer printouts of the results, which are often accompanied by lists of "normal ranges" and recommendations that the patient increase his or her ingestion of the elements that are deficient. All of this is accomplished without any knowledge of the patient's medical history and in spite of the absence of an accepted definition of what constitutes a normal range.[18,19] The American Council on Science and Health[3] recently published an anecdote about a study by a pharmacologic consultant to the US government who sent samples of hair from three healthy young men to three commercial laboratories: the reported results for each subject varied widely from laboratory to laboratory. Unfortunately, this anecdote is the only reported evidence of the unreliability of commercial analyses of hair.

Interpreting the results

The primary problem in interpreting the results of hair analyses is the lack of information about the normal range of concentrations of many trace elements in the hair[18,19] and the physiologic factors that may affect the concentrations; for example, the concentration of zinc in the hair of breast-fed infants is much lower than that in the hair of older children and adults.[20]

As well, little is known about the extent to which concentrations of specific elements in hair correlate with those in other organs, tissues, subcellular fractions and metabolic pools; for instance, the amount of zinc in the hair of rats correlates with that in the bone and testes but not with that in the blood, liver or kidneys.[21] However, the retention of zinc by hair has been reported to be similar to that by bone,[22] an observation that may be valuable in identifying children in whom zinc supplementation is thought to accelerate skeletal growth.[23] This may also explain why the concentration of zinc in the hair correlates well with the height of children in whom there is a high incidence of zinc deficiency.[24]

Finally, the sex, age and hair colour of the subject, as well as drugs taken, may affect the concentration of trace elements in hair.[25,26]

Uses of hair analysis

In spite of all the difficulties, analysis of hair for trace elements is used in four areas of study: environmental, forensic, nutritional and pathological.

Analysis of hair to estimate the level of exposure to toxic elements such as lead and cadmium[4,9,27] can be useful because samples can easily be collected from a large population and can be randomized so that variations in the site from which the sample was taken, differences between the amount of trace element on the surface of and within the hair shaft, and the sex, age and hair colour of the subjects are not major problems.[28-31]

In forensic medicine, hair analysis for trace elements can be used to prove recent poisoning,[32] misuse of drugs and ingestion of toxic substances.[33] Furthermore, toxic elements in the hair can be detected long after other tissues have decomposed.[34] It was once thought that hair found at the scene of a crime could be analysed and used to identify the criminal, but the effects of hair treatment and the site at which the hair grew "make it difficult to confirm unequivocally that a hair specimen belongs to a given person to the exclusion of any other".[6]

Nutritional studies have shown that malnutrition severe enough to cause marasmus or kwashiorkor may cause macroscopic changes in the colour, thickness and general appearance of hair. Microscopic assessment of the ratio of growing hair to resting or broken hair is particularly useful in identifying individuals with protein-energy malnutrition.[35] Low concentrations of zinc in hair and blood are also associated with nutritional deficiencies and short stature;[36] however, hair growth slows so severely in individuals with malnutrition that even when the concentrations of trace metals such as zinc are reduced in the plasma they may be normal in the hair.[37]

Analysis of hair for trace elements would be useful in monitoring the course of a disease if the analytic techniques were reliable and if concentrations of the elements in hair correlated with those in other tissues. For example, Jacob and colleagues[38] found a correlation between the concentrations of copper in the hair and those in the liver of rats. However, similar studies in humans have been disappointing: of 11 patients with primary biliary cirrhosis and high concentrations of copper in the liver only 1 had a high concentration of copper in the hair,[39] and none of a group of patients with Wilson's disease had abnormal quantities of copper in their hair.[40]

Summary

The analysis of hair for trace elements is potentially a safe, noninvasive and extremely useful diagnostic tool, but it has not yet been proven to be reliable or to reflect the status of trace elements elsewhere in the body. As well, little is known about the normal ranges of concentrations of elements in the hair or about the physiologic and pharmacologic factors that affect the concentrations. Until these problems have been resolved satisfactorily the diagnostic use of hair analysis performed by

commercial laboratories cannot be justified in clinical practice.

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