Hair Mineral Analysis to Define Past or Low Level Chronic Exposures

by: E. Blaurock-Busch, PhD

Hair mineral analysis (HMA) reflects how efficiently the root was nourished (or intoxicated) via the blood stream. As long as metals circulate, hair tissue will be supplied.

- This feeding and storing mechanism continues over time. Therefore, hair mineral levels reflect how well or poorly the hair tissue was supplied over time. While blood and urine testing reflects the present metal status only, HMA values indicate what happened over time.
- As long as toxins circulate in the blood stream, hair will be supplied. A 'normal' mercury or lead range in hair does not necessarily exclude a metal burden. If a metal such as Hg has fully crossed the blood brain barrier and no additional exposure exits, Hg will no longer be detected in the circulating blood stream. Or, if metals are tightly bound in tissue (such as fat tissue), little may find its way into blood or urine.
- Since mercury is no longer circulating and thus not supplying the hair root, it will not be detectable in hair either.
- This principle largely applies to metals capable of crossing the blood brain barrier.
- Some chelating agents such as DMSA (Dimercapto Succinic Acid) cross the blood brain barrier, binding metals, rerouting them back into the bloodstream where these metals *temporarily* circulate until excreted.
- This temporary circulation is often misinterpreted. Some chelation therapists believe that the redistribution of brain metals into the blood stream causes these circulating toxins to be transported to organ cells where they are stored, causing intoxication of other organ systems. This is a theoretical, but unlikely probability. If this possibility would exist, all chelation would lead to redistribution of chelator-bound metals into other organ cells. This is an unlikely scenario. When a metal is tightly bound to a chelating agent it will not be easily 'dropped'. If that were the case, chelation therapy would be endangering patients rather than detoxifying them; *it would not cause detoxification but metal redistribution and the end effect would not be an improvement in metal-related health problems as we generally see, but a change in metal-related health symptoms.*
- Hair tissue storage depends on the body's protein-metal binding ability, which decreases with age. This actually means that in older, grey-haired persons the bodily system is less likely to supply hair tissue with nutrients and toxins. In fact, hair mineral analysis of grey haired persons generally shows low-borderline metal concentrations. If elevated levels of any toxins are seen, we need to be concerned. The same is true for children. Light-haired children have a lower protein-metal-binding capacity, and again, elevated levels of any toxin are a sign of overexposure, and the exposure may have happened in utero. We often see high mercury hair levels in young children who have not been exposed during their lifetime. Investigation into the mother's history often indicates amalgam treatment during pregnancy, repeated immunization with thiomersal-containing vaccines, or high fish consumption as seen in Asian countries.

Improvement in method development and increased instrument sensitivity have improved the spectroanalysis of all specimen, including hair. Unfortunately, misinterpretation of hair mineral analysis results abound. By now, it is a well-established fact that sodium and potassium levels in hair do not represent a patient's nutritional status, but are generally an indication of an inadequate sample preparation process.

In spite of all the negative information, hair is a useful diagnostic tool for the evaluation of long term metal exposure and there is an accumulation of evidence that hair mineral analysis provides important information about chronic under-nutrition. While sample collection is rather simple, and no time constraint applies to the storage of hair, critical minds have lost interest due to negative publicity. This is unfortunate, because no other test allows us to view long term metal exposure with such ease.

With the hope to improve understanding, I let the following research summaries speak for this test. The essential statements of these excerpts have been trimmed without changing content or meaning. High-

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lighted parts are commented by the author, reflecting her opinion.

1. Arsenic and other elements in hair, nails, and skin-scales of arsenic victims in West Bengal, India. Samanta G., Sharma R., Roychowdhury T., Chakraborti D. Department of Civil and Environmental Engineering, University of Houston, N 107 Engineering Bldg 1, Houston, TX 77204-4003, USA. gsamanta@mail.uh.edu. Sci Total Environ. 2004 Jun 29;326(1-3):33-47.

For the first time, biological tissues (hair, nails, and skin-scales) of arsenic victims from an arsenic affected area of West Bengal (WB), India were analyzed for trace elements. Analysis was carried out by inductively coupled plasma-mass spectrometry (ICP-MS) for 10 elements (As, Se, Hg, Zn, Pb, Ni, Cd, Mn, Cu, and Fe). A **microwave digester** was used for digestion of the tissue samples. To validate the method, certified reference materials--human hair (GBW 07601) and bovine muscle (CRM 8414)--were analyzed for all elements. The W test was used to study the normal/log normal distribution for each element in the tissue samples. For hair (n=44) and nails (n=33), all elements show log-normal distribution. For skin-scale samples (n=11), data are not sufficient to provide the information about the trend. Geometric mean, standard error, and range for each element were presented and compared with literature values for other populations. This study reveals the higher levels of toxic elements As, Mn, Pb, and Ni in the tissue samples compared with available values in the literature. **The elevated levels of these toxic metals in the tissues may be due to exposure of these elements through drinking water and food.** This study reveals that in the arsenic-affected areas of WB, the concentrations of other toxic elements in drinking water and foodstuff should be monitored to evaluate the arsenic poisoning.

Comment: for about 10years now, closed vessel microwave digestion (see picture from our laboratory) is used to prepare hair samples for analysis. As a result, the accuracy of the analysis of elements such as arsenic, mercury, and selenium improved dramatically. Before microwave digestion, hair was acid digested in open vessels under heat. This caused the more volatile metals to escape, resulting in false low values of metals such as arsenic, mercury and selenium.

In addition, the old spectroanalysis via MS-ICP was not ideal for testing these halogenic metals. The newest MS-ICP are utilizing cell technique which provides a high analytical accuracy, even for the most difficult elements. In our recent governmental round-robin, we achieved a near 100% accuracy, something that was impossible with previous instruments.

Mechanism of modern MS-ICP

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Modern technique improved metal testing for all human and animal specimen, including hair samples. Hair analysis will not eliminate the need for blood or urine testing, but provides valuable information for the diagnosis of long term exposure.

2. Maternal Fish Consumption, Hair Mercury, and Infant Cognition in a U.S. Cohort

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Fish and other seafood may contain organic mercury but also beneficial nutrients such as n-3 polyunsaturated fatty acids. We studied whether maternal fish consumption during pregnancy harms or benefits fetal brain development. We examined associations of maternal fish intake during pregnancy and maternal hair mercury at delivery with infant cognition among 135 mother-infant pairs in Project Viva, a prospective U.S. pregnancy and child cohort study. We assessed infant cognition by the percent novelty preference on visual recognition memory (VRM) testing at 6 months of age. Mothers consumed an average of 1.2 fish servings per week during the second trimester. Mean maternal hair mercury was 0.55 ppm, with 10% of samples > 1.2 ppm. Mean VRM score was 59.8 (range, 10.9-92.5). After adjusting for participant characteristics using linear regression, higher fish intake was associated with higher infant cognition. This association strengthened after adjustment for hair mercury level: For each additional weekly fish serving, offspring VRM score was 4.0 points higher [95% confidence interval (CI) , 1.3 to 6.7]. However, an increase of 1 ppm in mercury was associated with a decrement in VRM score of 7.5 (95% CI, -13.7 to -1.2) points. VRM scores were highest among infants of women who consumed > 2 weekly fish servings but had mercury levels ≤ 1.2 ppm. **Higher fish consumption in pregnancy was associated with better infant cognition, but higher mercury levels were associated with lower cognition. Women should continue to eat fish during pregnancy but choose varieties with lower mercury contamination.**

Comment: Hair mineral analysis reflects long term exposure. It can be used to evaluate the mercury status in women before pregnancy occurs, allowing for nutritional corrections and adequate detoxification measures.

3.Mercury and Selenium Concentrations in Maternal and Neonatal Scalp Hair: Relationship to Amalgam-Based Dental Treatment Received During Pregnancy

Razagui I.B-A.; Haswell S.J. Biological Trace Element Research, Volume 81, Number 1, July 2001 , pp. 1-19 (19)

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Mercury and selenium concentrations were determined in scalp hair samples collected postpartum from 82 term pregnancy mothers and their neonates. Maternal mercury and selenium had median concentrations of 0.39$^{\mu}$g/g (range 0.1-2.13$^{\mu}$g/g) and 0.75$^{\mu}$g/g (range 0.1-3.95$^{\mu}$g/g), respectively, and corresponding median neonatal values were 0.24$^{\mu}$g/g (range 0.1-1.93 $^{\mu}$g) and 0.52 g/g (range (0.1-3.0$^{\mu}$g/g). **Amalgam-based restorative dental treatment received during pregnancy by 27 mothers (Group I) was associated with significantly higher mercury concentrations in their neonates ($p < 0.0001$) compared to those born to 55 mothers (Group II) whose most recent history of such dental treatment was dated to periods ranging between 1 and 12 yr prior to pregnancy.** In the Group I mother/neonate pairs, amalgam removal and replacement in 10 cases was associated with significantly higher mercury concentrations compared to 17 cases of new amalgam emplacement. Selenium concentrations showed no significant intergroup differences. The data from this preliminary study suggest that amalgam-based dental treatment during pregnancy is associated with higher prenatal exposure to mercury, particularly in cases of amalgam removal and replacement. **The ability of a peripheral biological tissue, such as hair, to elicit such marked differences in neonatal mercury concentrations provides supporting evidence of high fetal susceptibility to this form of mercury exposure.**

Comment: Transplacental movement of mercury has been documented. This is another study speaking against dental treatment with, or removal of, amalgam during pregnancy. It also supports infant hair testing.

4. Hair Element Concentrations in Females in One Acid and One Alkaline Area in Southern Sweden
Ingegerd Rosborg, Bengt Nihlgård, and Lars Gerhardsson . AMBIO: A Journal of the Human Environment. Vol 32, Issue No7, Nov. 2003 pp. 440–446

Concentrations of 34 trace elements in hair have been determined in 47 females from an acid region in southern Sweden, who were compared with 43 females from an alkaline area. The concentrations of these elements in hair and drinking water were determined by inductively coupled plasma optical emission spectroscopy and inductively coupled plasma mass spectrometry. **The hair concentrations of boron and barium were significantly higher ($p < 0.001$) in hair samples from the acid region, the hair levels of calcium, strontium, molybdenum, iron, and selenium were significantly higher ($p < 0.001$) in the alkaline region.** For some metals, e.g. calcium, lead, molybdenum, and strontium, there were positive correlations between the concentrations in hair and water ($r_s = 0.34–0.57; p \leq 0.001$), indicating the importance of intake from minerals in water. The increased ratio of selenium/mercury concentrations in hair samples obtained in the alkaline district ($p < 0.001$) indicates that these subjects may have better protection against the toxic effects of mercury.

Comment: Metal uptake is influenced by pH, a fact we recognize and pay attention to during chelation treatment.

5. Hair iron content: possible marker to complement monitoring therapy of iron deficiency in patients with chronic inflammatory bowel diseases?

E Bisse, F Renner, S Sussmann, J Scholmerich and H Wieland . Department of Clinical Chemistry, University Hospital, Freiburg im Breisgau, Germany. Clinical Chemistry, Vol 42, 1270-1274, Copyright © 1996 by American Association for Clinical Chemistry
Measurements of the concentration of iron in hair from 10 patients with chronic inflammatory bowel diseases and from 10 healthy controls showed that the iron concentrations were significantly ($P < 0.05$) lower in patients before iron intake than in controls. Three weeks after beginning iron treatment, the hair iron concentrations were found to be significantly correlated ($r = 0.68$; $P < 0.05$) to reticulocyte counts. **Changes in the hair iron concentrations were accompanied by similar changes in the concentrations of the markers most commonly used to diagnose and monitor iron deficiency. The results suggest that quantification of** hair **iron may be useful to complement evaluations of the body iron status.**

Comment: None needed.

6. Serum and hair trace element levels in patients with epilepsy and healthy subjects: does the antiepileptic therapy affect the element concentrations of hair?

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Abstract:

In this study, hair magnesium (Mg), zinc (Zn), copper (Cu), and manganese (Mn) levels, and serum Zn and Mg levels were measured by atomic absorption spectrophotometer in patients with epilepsy (n = 33) and healthy subjects (n = 21), and results obtained were statistically compared. The mean hair Cu, Mg, and Zn levels of epileptic patients were significantly lower than the levels of control subjects. There was no significant difference between epileptic patients and control subjects in respect to the mean Mn levels. Mean serum Mg levels in epileptic patients showed significant difference, but serum Zn levels were similar among both groups. When the effects of anticonvulsant therapy on Cu, Zn, Mn, and Mg in the hair, and Mg and Zn in the serum were analyzed in epileptics, there was no significant difference between the patients with or without therapy. Likewise, the mean trace element levels in epileptics showed no significant difference according to the type of antielpileptic drug and seizure, and gender. **We suggest that the changed element status (Zn, Mg, and Cu) in hair play an indicator role in the diagnosis of epileptic patients.**

Comment: Hair mineral evaluation of epileptic patients should be part of the patient evaluation process.

This article is an edited excerpt of the upcoming book, ***Antidota, Handbook of Chelation Therapy*** *(also called Clinical Metal Toxicology) by E.Blaurock-Busch, available through Micro Trace Minerals, Boulder, Colorado and Hersbruck, Germany.*

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