Mineral Interpretive Guide

Patient Handout

Description

Measuring concentrations of elements in erythrocytes provides a look at how well cellular levels are maintained because erythrocyte mineral levels reflect mineral status over a period of 3 months (the life cycle of an erythrocyte). Other specimens, like urine or plasma, are affected by daily dietary fluctuations.

In the process of their formation in bone marrow, erythrocytes acquire nutrient elements like zinc according to the availability of each element. The same may be said for the toxic elements, which means that high levels of these raise suspicion of chronic tissue penetration due to toxic exposure and inadequate detoxification mechanisms. All of the essential trace elements are dependent on stomach acid production for intestinal absorption.

No.	Name		Metabolic Association	Potential Intervention
Nutrient Elements				
1.	*Calcium*	*Ca*	Myriad cell regulatory effects	*See Calcium section*
2.	*Chromium*	*Cr*	Insulin target cell binding	200 - 400 µg/d
3.	*Copper*	*Cu*	Detox pathways	3 - 5 mg/d
4.	*Magnesium*	*Mg*	ATP energy transfer	200 - 400 mg/d
5.	*Manganese*	*Mn*	Biosynthetic pathways	5 - 15 mg/d
6.	*Molybdenum*	*Mo*	Xanthine oxidase	1 - 5 mg/d
7.	*Potassium*	*K*	Neuromuscular function	Fresh fruit & vegetables
8.	*Selenium*	*Se*	Antioxidant protection	200 - 1000 µg/d
9.	*Vanadium*	*V*	Cholesterol, triglycerides	200 - 1000 µg/d
10.	*Zinc*	*Zn*	Cofactor for numerous enzymes	15 - 60 mg/d
Toxic Elements			**Accumulation Site**	
11.	*Aluminum*	*Al*	Lung	Avoidance
12.	*Cadmium*	*Cd*	Kidney	Zinc
13.	*Lead*	*Pb*	Bone	Calcium
14.	*Mercury*	*Hg*	CNS/Brain	Selenium

The numbers in the left-hand column in the table correspond to those on the laboratory report of minerals in erythrocytes.

Calcium (Ca)

- Erythrocyte calcium is associated with the etiology of heart disease and stroke, as shown by erythrocyte morphological changes in ischemic vascular disease.
- Intracellular calcium content plays an important role in the induction of blood pressure elevation.
- Total erythrocyte calcium is elevated in hypertension and in postnatal hypoxic ischemic encephalopathy.
- Calcium levels in erythrocytes are not an accurate measure of calcium nutritional status because of the strong mechanisms maintaining the critical intracellular calcium concentrations independent of the total body calcium regulation exerted by parathyroid

hormone, vitamin D, and other regulatory molecules.

- Helps bones, teeth, helps heart, nerves, muscles, body systems work properly, needs other nutrients to function.
- Calcium is found in dairy, wheat/soy flour, molasses, Brewer's yeast, Brazil nuts, broccoli, cabbage, dark leafy greens, hazelnuts, oysters, sardines, canned salmon.
- Symptoms and problems of lacking calcium are Osteoporosis, osteomalacia, osteoarthritis, muscle cramps, irritability, acute anxiety, and colon cancer risk

Chromium (Cr)

- Chromium accumulates primarily in spleen and heart tissue.
- Dietary sources include liver, brewer's yeast, black pepper, whole grains, seafood, green beans, broccoli, prunes, nuts, potatoes, meat.
- The greatest number of chromium studies involves its role in glucose metabolism. Diabetic patients show lower hair chromium.
- Sugar metabolism was improved in over 80% of individuals with a slight glucose intolerance by using 200 µg/d chromium supplement.
- Chromium used in this way affects only those who are deficient in chromium.
- This nutrient impacts sugar metabolism through its role in uptake of insulin, and losses of chromium in urine are related to increased mobilization in response to the stimulus of frequent blood sugar peaks.
- Chromium also aids in lowering LDL cholesterol and raising HDL cholesterol.
- Increases fertility, carbohydrate/fat metabolism, essential for fetal growth/development.

Copper (Cu)

- Most copper is concentrated in liver, brain, and hair but is present in all other tissue. Best dietary sources are whole grains, nuts, seeds, beans, liver, and shellfish.
- Most of the copper present in erythrocytes is bound to the enzyme superoxide dismutase (SOD), which protects the cells from oxidative damage.
- Dietary deficiency of copper is seen as low levels of erythrocyte copper and SOD, even in early stages of copper depletion.
- Impairment of function due to copper deficiency may result from reduced activities of the enzymes, ceruloplasmin, monoamine oxidase, Lysyl oxidase in connective tissue, and SOD.
- Loss of these biochemical functions can lead to anemia, neural degeneration, lung and bone problems, CVD, and accelerated aging.
- In copper deficiencies, supplementation with 3-5 mg/d copper aspartate is helpful.
- Chronically elevated plasma copper may result in elevation of erythrocyte copper levels as well, although the two specimens represent different copper utilization.
- About 80% of erythrocyte copper is associated with SOD, while most plasma copper is bound to ceruloplasmin.
- Patients with Wilson's disease, an inherited copper accumulating disease, show elevated erythrocyte copper resistant to copper-lowering treatments.
- In these cases, copper accumulates in liver and brain where it causes tissue degeneration, apparently due to the stimulation of protein and DNA oxidative damage.
- Copper assists in bone formation, involved in healing process, energy production, hair and skin coloring, taste sensitivity, stimulates iron absorption, helps metabolize several fatty acids.
- Copper can be found in oysters, seeds, dark leafy vegetables organ meats dried

legumes, whole grain breads, nuts shellfish, chocolate, soybeans, oats, blackstrap molasses.

- Symptoms and problems associated with Copper are osteoporosis, anemia, baldness, diarrhea, general weakness, impaired respiratory function, myelopathy, decreased skin pigment, reduced resistance to infection.

Magnesium (Mg)

- Magnesium serves as a cofactor in approximately three hundred enzyme systems, making this element a critically important nutrient for many bodily functions including muscle/nerve function, immune system, strong bones,
- Symptoms and problems associated with Magnesium include hypertension, diabetes, PMS, appetite nausea, vomiting, fatigue ramps, numbness, tingling, seizures, heart spasms, personality changes, heart rhythm, neuromuscular tremors, fasciculations, and gross muscle spasms.
- Magnesium plays a vital role in normal cardiac function, and deficiency has been increasingly associated with cardiovascular disease.
- Some suggest hypomagnesemia is in itself atherogenic, and low magnesium levels in drinking water have been associated with increased risk of myocardial infarction.
- Magnesium has also been found to be useful in the treatment of congestive heart failure, tachycardia, and other arrhythmias.
- The magnesium content of red blood cells is a good indicator of short-term magnesium status and low levels indicate nutritional deficiency.
- Because of the requirement for magnesium by many enzyme involved in energy transfer, magnesium deficiency affects all tissues.
- As the largest energy user, nervous tissue shows the earliest signs of deficiency, with the appearance of dullness and listlessness, nausea and loss of appetite, alopecia (rapid hair loss), tremors, and convulsions.
- The major dietary sources of magnesium are nuts, seeds, beans, peas, whole unprocessed grains and dark green vegetables

Manganese (Mn)

- Manganese, like magnesium and zinc, is associated with a large number of enzymes in many areas of metabolism, especially those involved in connective tissue maintenance, fatty acid synthesis, and Krebs cycle pathways.
- Manganese deficiency contributes to glucose intolerance.
- Its absorption in the intestine is impaired by calcium, phosphate, and iron.Manganese is found in fruits, whole grains, and leafy green vegetables. High zinc dosing an suppress manganese.
- A ratio of 5mg manganese to 30 mg zinc is suggested

Molybdenum (Mo)

- Molybdenum is present in the body in extremely small amounts and is difficult to measure. The enzyme xanthine oxidase in the pathway that converts purines into uric acid requires molybdenum. Molybdenum is absorbed fairly well from the diet.
- It is abundant in whole grains and legumes.

Potassium (K)

- Erythrocyte potassium is the best single measure of body potassium status.
- Mild to moderate potassium deficiency is frequently found in those whose diet is low in fresh vegetables and fruit, especially if meat and fish intake is also low.
- Fortunately, the body has strong conservation mechanisms that dampen the effects of periods of low intake.
- Nervous and muscle tissues have strong requirements for potassium to maintain excitability.
- Depletion of body potassium can lead to a wide range of effects, including hypertension, heart arrythmias, and muscle weakness.
- The use of vegetable juices, citrus juices, bananas, melon, and other fruits and vegetables will increase potassium levels.

Selenium (Se)

- Selenium has a fairly narrow window of safe effectiveness and works closely with vitamin E.
- Protein-containing foods in which the selenium is bound to amino acids, such as meats and seafood, are good sources of selenium.
- Evidence shows that dietary intake of selenium is directly related to levels of selenium in erythrocytes. Low levels indicate depleted selenium pools.
- Selenium functions primarily as an activator of enzymes necessary for cellular protection from oxidative damage and maintenance of normal redox potentials.
- A primary role of selenium in erythrocytes appears to be the activation of the enzyme glutathione peroxidase, whereby glutathione (a critical antioxidant and antitoxin for all cells) reacts with oxygen radicals.
- Similarly, selenium catalyzes glutathione reductase, an enzyme that keeps glutathione in its reduced or active form.
- Selenium is an antioxidant, plays a role in the immune function, and prostaglandin production.
- Selenium can be found in brewer's yeast, wheat germ, liver, butter, cold water fish, shellfish, garlic, whole grains, sunflower seeds and Brazil nuts.
- Symptoms and problems associated with selenium deficiency are destruction to heart/pancreas, sore muscles, fragility of red blood cells and the immune system.

Vanadium (V)

- Recent data show vanadium to be essential for humans.
- Food concentrations vary greatly.
- Diets high in unsaturated oils have more vanadium than those high in saturated oils. Unrefined brown sugar has 1000 times more vanadium than white sugar.
- Food is generally low in vanadium. Absorption of vanadium is highly dependent on its form.
- It is retained by liver and bone and transported on the blood protein transferrin. Vanadium lowers cholesterol synthesis and may lower plasma triglycerides in humans. It promotes mineralization of bones and teeth and may protect against caries.
- Vanadium levels can become high due to environmental exposure to chemicals containing this element, as it is absorbed through inhalation.

Zinc (Zn)

- Sources of zinc in the diet include whole grains, nuts, seeds, red meat, poultry, beans, whole grains, fortified breakfast cereals, dairy, as well as seafood, especially oysters and shellfish.
- Zinc supports enzymes, wound healing, taste/smell, normal growth and development during pregnancy, childhood and adolescence.
- Growth and repair of any tissue is dependent on zinc as an activating cofactor for DNA/RNA polymerase.
- For this reason, zinc is vital to the normal healing of wounds and skin disorders.
- Dermatoses related to low zinc status are well-known; acrodermatitis, enteropathica is a severe deficiency seen in infants, and a milder form is seen in adults.
- Zinc is required for normal immune function.
- In fact, there are many similarities between the immunologic affects of zinc deficiency and those of AIDS.
- Low zinc is associated with low T helper lymphocytes. If intake of calcium, copper, or iron is excessive, tissue zinc may become depleted.
- If zinc is elevated, problems that might occur include iron non-responsive anemia due to related copper deficiency and increased vascular disease risk from lowered HDL cholesterol.
- Low zinc potentiates oxidative stress. Zinc is a potent antioxidant.
- A zinc deficient diet decreases total glutathione, vitamin E, GST, GSHPx and SOD levels.
- Zinc deficiency increases lipid peroxides and free radicals in tissue, mitochondria and cell membranes.
- Symptoms and problems associated with Zinc deficiency are growth retardation, hair loss, diarrhea, impotence, eye and skin lesions, loss of appetite, weight loss, wound healing, mental lethargy.

Toxic Metal

- Toxic metals exchange between blood plasma and erythrocytes after a person is exposed.
- The concentration of these metals in erythrocytes also is determined by the content of the tissue where erythrocytes originate: the bone marrow. The marrow exchanges the metals with the mineral matrix of bone.
- Thus, elevated erythrocyte levels of a toxic metal can reflect a deep tissue accumulation of the element.
- The distribution of elements between bone and various soft tissues varies with each element. For example, lead tends to preferentially deposit in bone, while cadmium concentrations are usually highest in kidney.
- No single tissue or body fluid provides the whole answer to total body toxic metal load. The question of why a patient has developed a high toxic metal load is frequently difficult to answer.
- Obvious sources of high exposure from industrial occupations where heavy metals are used are easily identified, but chronic low-level exposures escape notice.

Aluminum (Al)

- The best-known toxic effects of aluminum are dialysis encephalopathy and dementia inn uremic patients.
- These cases have provided valuable insight about other toxic effects of aluminum, including impaired memory, dementia, aphasia, ataxia, convulsions, and characteristic EEG changes.
- Urine is the major elimination route of aluminum, so once a chelating agent has mobilized and bound the element, it is relatively easily eliminated.
- Potential sources include antiperspirants, soda cans, baking soda, and toothpaste.

Cadmium (Cd)

- The fact that cadmium is bound by the abundant zinc-sequestering protein, metallothionine, and that this protein occurs in high concentration in kidney makes cadmium one of the most easily removed toxic elements.
- During chronic exposure, the kidney contains a major part of the body burden of cadmium. Any intervention that increases the passage of metal chelating agents through the kidney will lower total body burden of cadmium.
- Cadmium toxicity most clinically impacts the kidney, where damage to proximal tubules has been described.
- Also, cadmium compounds are classified as carcinogenic to humans. Potential sources include drinking water, processed foods, cigarette smoke, paint pigments, and silver polish.

Lead (Pb)

- Lead toxicity causes paralysis and pain in the extremities due to effects on demyelinization, axonal degeneration, and presynaptic block.
- Normocytic, sideroblastic anemia is the consequence of lead's inhibiting effects on enzymes in the heme biosynthesis pathway.
- Other clinical signs associated with lead toxicity are kidney damage, epigastric pain and nausea, and male and female reproductive failure.
- Lead toxicity commonly affects sensory, visual, auditory and cerebeller (coordination) functions, reflecting the nervous system impact of this element.
- Patients may have paraesthesia in the region around the mouth and in the hands immediately after exposure. Various intravenous chelation agents, including penicillamine and EDTA, have been shown to be effective of reducing lead body burden. Increase dietary calcium which helps lower the intestinal absorption of lead.
- Potential sources include leaded house paint, drinking water from lead plumbing, pesticides, and newsprint.

Mercury (Hg)

- Conditions ranging from childhood autism to adult neurological dysfunction and dementia can result from the toxic effects of mercury.
- Mercury tends to form very stable bonds with various amino acid side chains of proteins, making it difficult to remove quickly.
- The major part of mercury in blood is bound to hemoglobin in red cells.
- Sulfur-containing agents such as Dimercaptosuccinic acid (DMSA), are the most effective agents for removing mercury from tissues.
- The most important protective agent is dietary selenium, which helps reduce the toxic effects of mercury. Potential sources include dental amalgams, broken thermometers, cosmetics, and predator or fresh water fish.