**Cadmium Toxicity**

**Introduction**

Cadmium is an extremely toxic metal which has no known necessary function in the body. Cadmium toxicity contributes to a large number of health conditions, including the major killer diseases such as heart disease, cancer and diabetes.

Cadmium displaces zinc in many metallo-enzymes and many of the symptoms of cadmium toxicity can be traced to a cadmium-induced zinc deficiency.

Cadmium concentrates in the kidney, liver and various other organs and is considered more toxic than either lead or mercury. It is toxic at levels one tenth that of lead, mercury, aluminum, or nickel.

Cadmium toxicity is increasing in incidence today for several reasons. One of the primary reasons is a zinc deficiency in many commonly eaten foods. Zinc, which is protective against cadmium, is becoming increasingly deficient in the soil and consequently in foods. Food processing and eating of refined foods further reduces zinc intake.

Exposure to cadmium is also increasing due to its use as a coating for iron, steel and copper. It is also used in copper alloys, stabilizers in rubber and plastics, cigarette papers, fungicides and in many other products. Often these industries then pollute water, air and food with this metal.

**Sources Of Cadmium**

Food Sources

The most common sources of cadmium toxicity are foods such as rice and wheat which are grown in soil contaminated by sewage sludge, super phosphate fertilizers and irrigation water.

Large ocean fish such as tuna, codfish and haddock concentrate within their tissues relatively large amounts of cadmium. Oysters, although containing large amounts of cadmium also contain large amounts of zinc which serves to protect against cadmium toxicity.

Besides contaminated produce and organ meats such as liver and kidneys, a significant source of cadmium toxicity is a diet high in refined foods. Zinc, which normally protects against the toxic effects of cadmium, is largely removed during the milling process, leaving cadmium behind.

Candies, Processed And Refined Foods

Many processed foods have had the protective elements zinc and calcium removed in the refining process. Cadmium, however, remains and is readily absorbed since the zinc and calcium are not available to compete for absorption.

Cadmium may also be used as plating material in food-processing plants, thereby finding its way into processed food products. Processed meats, refined grains, instant coffee and cola drinks are among the most common sources of cadmium toxicity.

Widespread use of white flour and white rice, along with causing various vitamin and mineral deficiencies, contribute to cadmium toxicity by their high cadmium/zinc ratio. An excessive carbohydrate intake also serves to reduce tissue zinc levels, further aggravating a cadmium toxicity problem.

Canned Foods

Solder used to seal cans is a common source of cadmium.

Drinking Water

Cadmium used in industry finds its way into many water supplies. Soft water is more dangerous since the calcium in hard water has a protective effect. Old galvanized pipes and new plastic (PVC) pipes are sources of cadmium in our drinking water.

Batteries, Semiconductors, Electroplating, Polishes

Cadmium is used in numerous industries, in battery electrodes, semiconductors, etc. Workers in these industries are at risk of exposure. Dental amalgams and appliances may also contain cadmium.

Cigarette Smoke

One package of cigarettes deposits between two and four micrograms of cadmium into the smoker's lungs. Cigarettes are especially dangerous because cadmium is efficiently absorbed when inhaled.

Motor Oil, Exhaust, Incineration of Rubber Goods, Tires, Plastics and Paints

Cadmium levels are highest in urban areas where incineration takes place and where vehicle exhaust levels are higher.

**Congenital Cadmium Intoxication**

Cadmium was passed to the fetal rat brain when the pregnant mother was given a subcutaneous cadmium injection. We commonly observe high concentrations of cadmium in babies and young children, with no other possible source except from the mother.

Congenital cadmium toxicity is becoming increasingly common and probably helps account for the increase in birth defects, hyperkinesis, learning disorders, minimal brain dysfunction and the failure to thrive syndrome.

**Detection Of Cadmium**

Blood Tests

Even when high dietary cadmium is fed, the blood level of cadmium remains extremely low. Even intravenously injected cadmium rapidly disappears from the blood. Consequently, cadmium data from blood have little diagnostic value.

Challenge Tests

Chelating agents may be given and a 24-hour urine sample collected to detect cadmium in arteries and blood. However, cadmium which is stored in the liver, bones, joints and other tissues will not be detected using challenge tests.

Hair Analysis

Cadmium levels in the hair show statistically significant correlations with cadmium levels in the kidneys.

However, excessive tissue cadmium is often not revealed on the first mineral test. As with the other toxic metals, cadmium can be so tightly bound that it may require months or even several years on a nutritional program before cadmium is released from storage and is revealed on a hair analysis.

**Metabolism Of Cadmium**

Absorption

Absorption of cadmium is highest through inhalation. Women are more prone to cadmium toxicity than men. This may be due to the fact that females in general tend to have a lower metabolic rate than males.

Dietary absorption of cadmium is favored by a deficiency of calcium, zinc, copper, iron and protein in the diet.

Retention

About 50 percent of ingested, or inhaled cadmium is stored in the liver and kidneys. High concentrations of cadmium are also deposited in the pancreas and salivary glands. Other storage sites may also include the joints, arteries, periosteum or covering of the bones and virtually all body tissues.

In the blood, cadmium moves from the plasma to the red blood cells, where it binds mainly to metallothionein and hemoglobin.

Cadmium ingestion stimulates production of metallothionein, a zinc and cadmium binding protein.

The cadmium content of the body increases with age in industrialized societies, from less than 1 mcg. in the newborn, to 15-20 mg. in adults.

Excretion

Metallothionein plays an important role in the excretion of cadmium, inasmuch as it acts as a chelating agent. Excretion of cadmium occurs through the kidneys and liver, but the excretion rate is normally very low. The biological half-life of cadmium is probably between 10 and 30 years.

**Metabolic Effects Of Cadmium**

Effects On Energy Production

Cadmium is a well-known inhibitor of cellular respiration. It forms strong covalent bonds with many bio-molecules and so its potential targets for damage are numerous. Some of the most vulnerable enzymes are glutathione reductase and the enzymes of the Krebs energy cycle - pyruvate and a-ketoglutarate dehydrogenase.

Displacement Of Zinc

Many of the toxic effects of cadmium including kidney disease, neurological damage, arteriosclerosis and birth defects stem from replacement of zinc in sensitive enzyme binding sites.

Metallothionein binds zinc and copper as well as cadmium. Cadmium binds more tightly to metallothionein, and as a result, less copper and zinc are bound which results in a copper and zinc deficiency. Since binding to metallothionein is necessary for utilization of zinc and copper, cadmium poisoning can lead to a zinc and copper deficiency.

An interesting aspect of cadmium poisoning is that by replacing zinc in critical enzyme systems; cadmium can perform a homeostatic function. That is; many zinc-dependent enzymes can continue to function to a certain extent with cadmium instead of zinc. However, enzymatic activity is reduced and problems eventually occur as a result of impairment of the zinc-dependent enzymes.

Renal Effects

Many of the toxic effects of cadmium stem from its accumulation in the kidneys. Renal dysfunction affects calcium, vitamin D, phosphorus and sodium levels, resulting in proteinuria, glycosuria, renal hypertension and other metabolic disorders.

Carcinogenesis And Teratogenesis

Cadmium has been suggested as an etiologic factor in certain human cancers. Birth defects, probably due to zinc deficiency, have been observed in mice, rats and hamsters.

**Metabolic Dysfunctions Associated With Elevated Cadmium**

It is difficult to ascribe metabolic dysfunctions to cadmium toxicity alone; inasmuch as many metabolic dysfunctions are the result of displacement of zinc, or a zinc deficiency. However, the major categories of metabolic dysfunctions associated with cadmium toxicity include:

Nervous System

Neurotransmitters: Cadmium inhibits release of acetylcholine, probably by interfering with calcium metabolism. Cadmium also activates the enzyme cholinesterase, while zinc inhibits cholinesterase activity. Cooper and Steinberg concluded that cadmium at any dose was a more potent blocking agent of cholinesterase activity than lead.

Adenylate cyclase and monoamine oxidase activity is inhibited by cadmium. Uptake at synapses of choline, catecholamines, gamma-aminobutyric acid (GABA) and glutamic acid is inhibited.

Cadmium also inhibits the methylation of phospholipids, interfering with cellular membrane functions.

Other damage: Cadmium causes hemorrhages in the autonomic ganglia with secondary nerve cell necrosis. Also reported is direct damage to nerve cells, particularly nerve fibers.

Peripheral neuropathy can also result.

Musculo-Skeletal System

Alterations in calcium and phosphorus metabolism can result in osteoporosis, osteomalacia and arthritic conditions. Interference with zinc metabolism can result in neuromuscular dysfunctions associated with a zinc deficiency.

Cardiovascular

Cadmium replaces zinc in the arterial walls, leading to reduced flexibility and strength of the arteries. The body then will coat the arteries to prevent aneurysms, resulting in atherosclerotic plaque, narrowing of arteries and hypertension.

Digestive System

Interference with zinc-dependent enzymes such as carboxypeptidase can result in impaired digestion.

Reproductive System

Cadmium may contribute to prostate difficulties and impotence problems by interfering with zinc enzymes and by interference with cellular energy production.

Endocrine/Metabolic System

Growth impairment and the failure to thrive syndrome are often associated with cadmium toxicity. Zinc is essential for normal growth.

Excretory System

The major storage sites of cadmium are the kidneys. It is not known whether the cadmium itself or the cadmium bound to metallothionein is responsible for tubular damage, which can result in high blood pressure and other renal disease.

Dental

Alterations in calcium and vitamin D metabolism can result in dental caries and tooth deformities.

Mental/Psychological

Cadmium is associated with hyperactivity and learning disability, most likely due to a cadmium induced zinc deficiency. Inhibition of acetylcholine release may also result in hyperkinetic behavior.

**Metabolic Dysfunctions Associated With Cadmium Toxicity**

Alcoholism

Alcoholism is frequently associated with a zinc deficiency and with hypoglycemia. Cadmium may be implicated in alcoholism, principally due to its effect upon zinc metabolism.

Alopecia

Alopecia (loss of hair) is commonly associated with a cadmium-induced zinc deficiency.

Anemia

Anemia is an early sign of cadmium toxicity.

Atherosclerosis

Zinc is necessary for the optimal metabolism of fats. By interfering with zinc levels, cadmium toxicity can contribute to atherosclerosis.

Arteriosclerosis

Zinc is required to maintain the normal elasticity of arteries. By displacing zinc, cadmium causes the arteries to become less elastic and therefore more vulnerable to rupture. The body may then deposit calcium plaques to help strengthen the arterial walls.

Arthritis, Osteo and Rheumatoid

Displacement of zinc by cadmium results in impaired protein synthesis. Inadequate protein synthesis interferes with regeneration of joint surfaces, which leads to pain and inflammation of the joints.

Bone Repair, Inhibited

Zinc is required for bone repair. Cadmium can also displace calcium in bone structures.

Cancer

Cadmium toxicity is intimately associated with various malignancies. A high percentage of cancer patients on tissue mineral analysis programs, at one time or another, reveals cadmium toxicity. Interference with zinc-dependent enzymes may be the link to malignancy.

Cardiovascular Disease

Dr. Isabel H. Tipton at the University of Tennessee noted that victims of cardiovascular disease, particularly stroke victims, had high levels of cadmium in their body tissues.

Cerebral Hemorrhage

Weakness and hardening of cerebral arteries, due to cadmium toxicity, results in an increased tendency for cerebral hemorrhage.

Cirrhosis of the Liver

Zinc deficiency due to cadmium impairs detoxification of alcohol in the liver, which may explain the connection between cadmium toxicity and liver cirrhosis.

Diabetes

Zinc is required for the production, release and transport of insulin. By interfering with zinc metabolism, cadmium can initiate or aggravate a diabetic condition.

Emphysema

Cadmium from cigarettes acts as a lung irritant. Cadmium also replaces zinc in collagen, causing brittleness and breakage of the fragile alveoli in the lungs.

Enlarged Heart

An enlarged heart is often secondary to narrowed arteries and high blood pressure. Cadmium toxicity is a common contributor to these cardiovascular conditions.

Fertility, Decreased

Zinc is critical for male fertility. Sexual potency is decreased, due to a cadmium-induced zinc deficiency.

Hemochromatosis

This disorder involves deposition of excessive iron in the tissues. Hemochromatosis may be due to inadequate ability of the liver to detoxify iron. Cadmium toxicity may impair the ability of the liver to detoxify iron. A deficiency of zinc and copper due to cadmium toxicity may also be involved in this disorder.

Hypercholesterolemia and Hyperlipidemia

By causing a zinc deficiency, excess cadmium can cause a rise in cholesterol levels.

Levels of other fats may be adversely affected if liver function is impaired by cadmium toxicity.

Hypertension

High levels of cadmium are considered to be an important causative factor in hypertension. Cadmium, by impairing kidney function and causing hardening of the arteries, can result in high blood pressure.

Hypoglycemia

A zinc deficiency, secondary to a cadmium toxicity, is a frequent cause of hypoglycemia.

Inflammation

Cadmium causes an increased retention of sodium by way of its action on the kidney. This aldosterone-like effect is capable of inducing an inflammatory process.

Also, zinc has an anti-inflammatory effect. Zinc deficiency due to cadmium toxicity can increase inflammation.

Libido, Decreased

By interfering with zinc metabolism, cadmium can cause impotency or decreased libido.

Lung Disease

Cadmium can adversely affect the elasticity of lung tissue.

Migraine Headache

By interfering with zinc metabolism, cadmium toxicity may allow tissue copper buildup to occur, resulting eventually in the causation of migraine headaches.

Osteoporosis

High levels of cadmium can cause demineralization of the bones and total inhibition of bone repair mechanisms. Zinc is essential for bone mineralization.

Renal Arteriosclerosis

Cadmium concentrates in the kidneys, thus contributing to renal arteriosclerosis.

Renal Dysfunction and Hypertension

Cadmium has a unique tendency to concentrate in the human kidney. There it can cause renal hypertension and proteinuria. Cadmium acts directly on the kidney to enhance sodium and water retention. No other substance, save aldosterone, is known to enhance resorption of sodium.

Schizophrenia

Cadmium-induced schizophrenia is most likely due to displacement of zinc. Zinc is a central nervous system stabilizer and is now considered a neurotransmitter substance. A low zinc level may result in mood alterations and can allow copper to accumulate in excess in the brain. Copper toxicity is linked to a specific type of schizophrenia.

Vascular Disease - Strokes (cerebral vascular disease)

When cadmium replaces zinc in the cerebral arteries, vascular elasticity is diminished. Frequently the body coats the weakened arteries with fatty or calcium plaques to protect against rupture of the artery. If a bit of plaque or cholesterol breaks free, it can lodge in a cerebral artery, causing a stroke.

**Metabolic Dysfunctions, Signs And Symptoms That Can Be Caused By A Cadmium-Induced Zinc Deficiency**

|  |  |  |
| --- | --- | --- |
|  | Acne | Hair-coarse in eyebrows |
|  | Alcoholism | Hair growth, decreased |
|  | Amenorrhea | Influenza |
|  | Atherosclerosis | Leukemia |
|  | Appetite (loss of) | Liver damage |
|  | Back pain, low | Prostatitis |
|  | Bone Disorders | Psoriasis |
|  | Colds | Retinal detachment |
|  | Cholesterol, elevated | Reye's Syndrome |
|  | Cirrhosis of liver | Schizophrenia |
|  | Circulation, poor | Sexual ardor diminished |
|  | Cutaneous striae | Skin lesions |
|  | Diabetes | Taste, lost sense of |
|  | Eczema, facial | Ulcer, stomach |
|  | Epilepsy | Vascular disease |
|  | Fatigue | Wound healing, delayed |
|  | Fertility, decline in |  |

**Effects On Other Minerals**

Displacement Of Zinc

As described above, cadmium can replace zinc in many metallo-enzyme binding sites.

Disruption Of Calcium And Phosphorus Metabolism

Cadmium deposited in the kidneys disturbs the calcium and phosphorus balance, probably by altering vitamin D metabolism. A disturbance in the calcium/phosphorus ratio can result in osteoporosis, osteomalacia and pseudo-fractures.

Cadmium has a potent inhibitory effect upon calcium incorporation, even when dietary calcium intake is adequate. This may be due to inhibition of 1,25 dihydroxycalciferol by the renal tubules.

Effects On Sodium Levels

By damaging the filtering capacity of the renal tubules, cadmium causes sodium retention which can contribute to a wide array of disorders ranging from hypertension to hyperactivity.

Reduction Of Copper In The Liver

Cadmium reduces copper levels in the liver. Cadmium binds more tightly to metallothionein than does copper. Because copper is not adequately bound, it becomes biounavailable.

Manganese

Hepatic and renal manganese are apparently increased by cadmium.

**Effects Of Other Nutrients On Cadmium**

Zinc

Zinc is a cadmium antagonist. Adequate zinc in the diet affords some protection from exposure to cadmium. Zinc may also be administered to assist in detoxifying cadmium.

Calcium And Vitamin D

Adequate calcium and vitamin D intake can help prevent or reverse the osteomalacia induced by cadmium toxicity. Presumably cadmium causes disruption of calcium metabolism by altering vitamin D metabolism in the kidney.

A calcium deficiency results in increased cadmium absorption from the intestines and its subsequent deposition in bone and soft tissues.

Copper

Copper competes with cadmium for absorption in the gut. Copper also enhances recalcification of bones, helping to reverse cadmium-induced osteoporotic changes.

Iron

Adequate dietary iron protects against cadmium absorption.

Selenium

Induction of testicular tumors and sarcomas by cadmium is inhibited by selenium.

Manganese

Manganese when taken with appropriate amounts of zinc and copper exerts a protective effect against low levels of cadmium toxicity.

Vitamin C.

Large amounts of vitamin C have been found to prevent signs of cadmium poisoning in quail.

Protein

Different sources of protein are more effective in protecting against cadmium toxicity than others. Egg white had a more protective effect than casein, soy, or gelatin, probably due to the high amounts of selenium in egg white.

A low protein intake can contribute to an increased cadmium toxicity.

Pyridoxine

Pyridoxine (vitamin B-6) appears to increase the toxic effects of cadmium, probably by enhancing its absorption.

**Detoxification Of Cadmium**

Although the medical literature states that cadmium toxicity is largely irreversible, we have had excellent success in reversing cadmium-induced pathology using the mineral balancing approach.

The nutritional method involves several aspects, all of which must be combined for greatest effectiveness.

**Improving Energy Levels**

The most important principle for correcting cadmium toxicity is increasing biochemical energy production, which frees more energy for all normal metabolic activities. This is accomplished by precisely balancing the tissue electrolyte levels and ratios as revealed in an unwashed hair sample.

Antagonists

Dietary cadmium absorption can be reduced by administration of iron, zinc and copper. Zinc and calcium are cellular antagonists to cadmium. Selenium appears to reverse certain effects of cadmium toxicity.

Chelating Agents

Vitamin C can bind cadmium and facilitate its removal. Sulfur compounds may also be helpful. EDTA therapy is used by some doctors to remove cadmium from the kidneys.

**Improving Channels of Elimination**

Any therapy which improves the activity of the kidneys will assist detoxification of cadmium. Kidney glandular substance, combined with synergistic factors, to support kidney activity has proven to be effective.

**Diet**

Diet plays an important role not only in avoiding sources of cadmium including refined and contaminated foods, but also to help balance the oxidation rate and provide adequate protein, minerals and vitamins.

**Reduce Exposure**

Occupational cadmium exposure, cigarette smoking and ingestion of cadmium-contaminated foods should be discontinued.

**Combined Therapy**

While these methods seem simple enough, their application at times is complex because cadmium may perform an adaptive function by raising sodium levels. In order to reduce cadmium levels, the need for this adaptation must be removed.

Over the years, we have researched many aspects of cadmium detoxification and have identified those nutrients which are most effective.

The dosage of manganese, iron, calcium, zinc, inositol, choline, methionine, vitamin C, selenium and other nutrients should be adjusted for each individual. A hair mineral retest should be done every three months to maintain optimal mineral ratios and levels to assure optimal results.

**Protection Against a ‘Cadmium Crisis’**

The active removal of cadmium from tissue storage occasionally results in a cadmium crisis which causes disagreeable symptoms. These symptoms may include fatigue, metallic taste in the mouth, low back pain, stomach distress, poor appetite, skin eruption and/or headache.

These symptoms are temporary, but can be reduced or eliminated by increasing the intake of vitamin C and calcium. The dosage of vitamin C and calcium during a crisis period can be increased to 3000 mgs. for vitamin C and 1600 mgs. for calcium. The dosage can be reduced as symptoms subside.

References:

* Cranston & Passwater, Trace Elements, Hair Analysis, And Nutrition, Keats Publishing, Inc., New Caanan, CT, 1983.
* Larson and Piscator, 1971; Itokawa et al., 1974; Pond and Walker, 1975.
* Linder, M., ed., Nutritional Biochemistry and Metabolism, Elsevier Science Publishing Co., Inc., New York, 1985.
* Nriagu, J. O., ed., Changing Metal Cycles and Human Health, Springer-Verlag, 1984.
* Pfeiffer, C., Mental and Elemental Nutrients, Keats Publishing Co., New Canaan, Ct., 1975.

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