

CADMIUM

Introduction

The element cadmium (Cd) is chemically similar to zinc and is found in soils and in deposits of zinc, copper and lead ores. Environmental pollution with cadmium has been taking place for several thousand years, ever since man started to produce metals from ores that happened to contain cadmium. However, the toxicity of cadmium has only been recognized for a relatively short time – since the 1970's [1].

Humans absorb 5 – 10 % of ingested Cd, but a low intake of calcium, zinc or iron increases the degree of absorption. Subjects who are iron-deficient, for example, may absorb an increased proportion of the Cd they ingest (principally from food, water and tobacco smoke). The absorbed Cd accumulates in the tissues, with a particularly long half life of 10 – 30 years. Transport of Cd in the plasma water is by binding to albumin or metallothionein; on reaching the kidney, metallothionein is small enough to be filtered at the glomerulus and then re-absorbed by the renal tubular cells, leaving Cd to be excreted in the urine [1]. The excretion process can itself cause renal tubular damage. However, as the reported age-related accumulation of Cd in the body shows [2], only a small portion of the Cd absorbed from long-term, low-level exposure will ever actually be excreted from the body.

Physiological actions of cadmium

No essential physiological function has been proposed for Cd. However, it has physico-chemical similarities to zinc, which allow Cd to compete with zinc as a co-factor for zinc-dependent enzymes such as alkaline phosphatase [3], resulting in reduced activity of those enzymes. Cd also has transitional metal activity and can thus promote oxidative reactions in the tissues in which it has been sequestered.

Cd particularly accumulates in the bone and the kidney, but its adverse health effects can now be demonstrated in almost every organ and tissue where it accumulates.

Toxic effects of cadmium

Environmental exposure to cadmium decreases bone density indirectly through loss of calcium in the urine as a result of renal tubular dysfunction. The primary symptom of prolonged exposure to high-dose cadmium is weak, brittle bones with spinal and leg pain ("itai itai disease"). Other complications include anemia and renal failure [1]. Cadmium at lower levels of exposure has been linked to osteoporosis, particularly in post-menopausal females [4].

Accumulating evidence also links environmental exposure to cadmium with an increased incidence of cancer affecting many different organs. For example, prospective studies in Japan and the United States have shown that excess cancer mortality is associated with environmental exposure to cadmium [5,6,7]. A Swedish study in 2008 [8] reported increased endometrial cancer risk among participants in a cohort who consumed > 15 µg/day of cadmium, mainly derived from cereals and vegetables. There are many other current studies in the literature linking cadmium and cancer in non-occupationally exposed populations and, overall, these findings suggest a very large adverse health effect from exposure to cadmium at low levels of intake.

Recent epidemiological studies also link exposure to Cd to effects in newly identified target organs. Cadmium exposure has been linked to diabetes [9], diabetic nephropathy [10], hypertension [11], peripheral artery disease [12], myocardial infarction [13], diminished lung function [14], periodontal disease [15], and age-related macular degeneration of the eye [16]. Evidence from other studies has suggested causal relationships between cadmium exposure and all-cause mortality, as well as between cadmium exposure and excess cancer mortality. This suggests that cadmium is at least a co-morbidity factor in a number of conditions such as cancer of the lung, pancreas, breast, endometrium, prostate and bladder.

The current Health and Safety criteria used in the U.K. to assess Cd toxicity depend solely on the effect of Cd on the kidney to assess the health risk from ingestion of the metal [17]; however, increasing evidence implicates cadmium as a risk factor for diseases that involve other tissues and organ systems at cadmium concentrations that do not produce effects on renal function or on bone.

Food sources of cadmium

Because of its high rates of soil-to-plant transfer, cadmium is a contaminant found in most human foodstuffs, which makes the diet a primary source of exposure among non-smoking, non-occupationally exposed populations [18,19]. Vegetables grown using water from industrial effluents may therefore be especially rich in Cd, as will vegetables grown in city environments polluted with smoke from motor vehicles.

Cadmium in clinical samples

The reference intervals for cadmium are as follows:

Urine Cd (for monitoring the body burden of Cd)	<1.00 µmol/mol of creatinine
Whole blood Cd (for recent Cd exposure)	< 27 nmol/L
Hair Cd (reflects 3 months' exposure to Cd)	< 0.10 µg/gm of hair

Tobacco is a significant source of cadmium and blood Cd levels in smokers with no other significant excess exposure may be up to 54 nmol/L. Blood Cd concentrations above 90 nmol/L suggest recent industrial exposure (from dust, fumes, solders, batteries etc.).

Patient preparation:

No special preparation is required and the patient can continue to take nutritional supplements and medication before the collection of the sample.

Specimen requirements

For blood cadmium measurement, the sample should be collected into an 8 ml trace element-free potassium EDTA tube. Collection tubes and needles can be supplied. If a number of blood tubes are being taken at the same collection, the trace element-free tube should be filled first to avoid cross-contamination. Postal samples (overnight delivery) are acceptable.

A 24-hour urine collection is preferred for urine cadmium determination, but a random urine sample is acceptable. The total volume collected should be recorded and, after mixing, 15 mL of urine should be submitted in a plastic, screw cap container. A postal sample kit can be supplied.

For hair analysis, hair should be cut from the nape of the neck, as close to the scalp as possible. At least 0.5gm of hair is required, which is about one heaped tablespoon full. Only hair up to 1½" (4cm) from scalp can be used. Please allow for this when the hair is long by sending in a larger total sample, for example 2 tablespoons-full of hair.

Turn around time: 5 working days.

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