



Beryllium

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Introduction

Elemental beryllium (Be), the second lightest of all metals, has a wide variety of applications; as well as being light weight, it is extremely stiff. Beryllium's properties are critical to a number of industries, including the computer, aerospace and nuclear industries; the number of manufacturing processes that use beryllium is continuously expanding. Beryllium was also once known as glucinum [1], which means "sweet", since beryllium and many of its compounds have a sugary taste; unfortunately for the chemists who discovered this property, beryllium is also poisonous (though poorly absorbed).

Toxicity

Beryllium is present in soils, in coal and in oil, and its dust enters the air from, in particular, the burning of coal and oil. Be can enter the body via the lungs, which form the main target organ of its toxicity. If Be air levels are high enough (greater than 1000 $\mu\text{g}/\text{m}^3$), an acute lung condition can develop (acute beryllium disease). Some individuals who are readily sensitized to beryllium may develop a chronic beryllium disease when they are occupationally exposed to the metal. Symptoms include chronic fatigue, difficulty in breathing, anorexia, weight loss, and heart disease. Chronic beryllium disease is a cell-mediated (delayed) hypersensitivity reaction, characterized by granuloma formation and pulmonary fibrosis - which may be fatal [2].

Beryllium compounds may also cause a contact dermatitis [3], which is can be problematic, given the widespread use of Be in dental restorative materials.

Environmental exposure to beryllium

After inhalation of beryllium, large numbers of CD4⁺ lymphocytes accumulate in the lungs. These helper T cells demonstrate a marked proliferative response on exposure to beryllium. A recent study found that a genetic factor, a glutamic acid at position 69 (E69) of the HLA-DP β chain, together with exposure to Be contribute to the odds of developing chronic beryllium disease and beryllium sensitization [4]. Inhaled beryllium is solubilized in the lungs and distributed to the bone, liver and kidneys. However, other organs can become involved, including extra-pulmonary lymph nodes, skin, salivary glands, the myocardium, and skeletal muscle. Continuous surveillance of the effectiveness of skin protection is required to prevent sensitization of those exposed to the metal in high-risk industrial processes [5].

Beryllium sensitisation

The beryllium-induced macrophage apoptosis that characterises Be sensitisation is thought to be due to Be-stimulation of reactive oxygen species production [6]. Beryllium sensitisation has been shown to progress to chronic beryllium disease [7].

Metal sensitisation has historically been diagnosed using epicutaneous patch testing [8]. Patch testing may, however, yield false positive or false negative results, and, as an *in vivo* test, may exacerbate symptoms in a sensitised subject. An alternative is an *in vitro* lymphocyte transformation test, optimised as MELISA (an acronym for memory lymphocyte immunostimulation assay) [9].

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Specimen requirements

Blood for beryllium analysis should be collected into a trace element-free (dark blue top) BDH venoject tube. For urine determinations a sample from a 24-hour or 6-hour urine collection should be submitted. Blood for MELISA testing should be taken into sodium citrate tubes (two 9 ml venoject tubes provide sufficient blood for testing up to 3 metals).

Methodology

Beryllium determinations are carried out by inductively coupled plasma-mass spectrometry (ICPMS).

Interpretation of results

Transport and distribution of beryllium in the body takes place through the blood, with the major portion of the metal bound to pre-albumin and globulin. Excretion of beryllium is primarily through the urine, with a long biological half life and very little elimination by the biliary-faecal route. However, most beryllium taken in orally is not thought to be absorbed by the gut and passes out through the faeces [2]. Both blood and urine measurements can be used to monitor beryllium exposure and absorption.

The best test for beryllium sensitivity is the MELISA stimulation index.

The reference interval for whole blood Be is ≤ 30 nmol/L.

The reference interval for urine Be is ≤ 7.8 $\mu\text{mol/mol}$ creatinine.

There is no established statutory maximum permitted level for Be in drinking water.

Results for the in vitro lymphocyte transformation test (MELISA) are expressed as a stimulation index for lymphocyte proliferation on exposure to beryllium; a value for this index of less than 2 is negative, while a value between 2 and 3 suggests a borderline sensitisation to beryllium. A sensitisation index of between 3 and 10 is a positive response, while a value of greater than 10 is a strong positive response. Measurement of beryllium reactivity in the lymphocytes of occupationally exposed individuals is the most reliable method of detecting susceptibility to chronic beryllium disease [10].

References

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