



Cobalt

December 2013

Introduction

Cobalt is a group 9 transition metal, with magnetic properties similar to those of iron. It was originally isolated by George Brand, of Sweden, in 1735, who had been trying to demonstrate that the blue colour of glass was due to a new element, cobalt, rather than bismuth, which is often found in the same locations as cobalt. The name is from the German word “kobald” or “goblin”. Cobalt salts give glass and pottery a deep blue colour and were of value to the early civilisations of Egypt and Mesopotamia for that purpose.

Cobalt’s other uses include being mixed with iron, nickel and other metals to make alloys of high magnetic strength, in stainless steels and in electroplating. Cobalt-60, an artificial radio-isotope, is an important γ ray source, and has been extensively used as a tracer and a radiotherapeutic agent.

The biological role of cobalt is in the “corrin” nucleus of vitamin B₁₂ (cobalamin), which is synthesised by micro-organisms and which enters the human diet with food of animal origin. However, most of the cobalt in the human diet is inorganic, with vitamin B₁₂ only representing a small fraction [1]. The main human food sources of cobalt are molluscs and beef liver.

Toxicity

Cobalt does not accumulate in the tissues and is rapidly excreted via the urine after ingestion; the concentration of cobalt in blood or urine can therefore be used as a marker of recent exposure to cobalt. By virtue of its transition metal properties, cobalt can participate *in vivo* in free radical-generating Fenton and Haber-Weiss chemistries, enhancing its toxicity. The lung is the main target of its toxicity, but the heart, the thyroid gland and the haematopoietic system and are also potential targets. Cobalt stimulates erythropoiesis [2], increasing both the blood volume and the number of erythrocytes. In spite of its potential toxicity, cobalt chloride has been used to treat anaemia [3].

In the 1960’s a Canadian brewery introduced a new brewing process that used cobalt chloride to maintain the stability of the frothy head on its beer: there were a significant number of fatalities among heavy drinkers before this was withdrawn [4]. Death was from heart failure, with cardiomyopathy, polycythaemia and thyroid lesions.

Urinary cobalt excretion sufficiently high to suggest toxicity is sometimes observed at Biolab from the analysis of specimens from subjects taking excessive supplemental vitamin B₁₂ or multivitamin tablets; this phenomenon is also recognized in the literature [1].

Cobalt and metal-on-metal hip implants

Metal-on-metal hip prostheses can, as they break down in the body, produce adverse local and systemic effects. Immunological reactions to such metal debris and metal ions are now well recognized and can be subdivided into 2 categories - “metal reactivity” and “metal allergy”. “Metal reactivity” is a normal immunologic response to a large amount of metal debris and is the most common local adverse reaction, developing with increased wear. The second category, “metal allergy,” is an adaptive immune response

manifested as a delayed type IV hypersensitivity, a rare abnormal response to a small amount of metal debris that occurs in people with a genetic allergic predisposition to this type of hypersensitivity.

Several cases with systemic manifestations of Co toxicity from metal-on-metal implants have been described as “arthroprosthetic cobaltism.” This syndrome includes various neurological manifestations, such as headache, visual impairment, optic nerve atrophy, hearing loss, vertigo, tasting disorders, as well as hypothyroidism, and cardiomyopathy [5].

However, patients with well functioning metal-on-metal joints may have significantly elevated blood levels of cobalt (e.g. up to 30 nmol/L) without apparent adverse health effects, which suggests that some subjects can tolerate blood cobalt levels well above the B₁₂-related reference interval.

Specimen requirements

Urine samples for cobalt analysis should be taken from a 24-hour or 6-hour collection.

For blood cobalt measurement, the sample should be collected into an 8 ml trace element-free potassium EDTA tube. Collection tubes and needles can be supplied by Biolab. 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.

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.

Methodology

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

Interpretation of results

Both blood and urine measurements can be used as indicators of exposure to cobalt.

The reference interval for urine cobalt is ≤ 9.0 umol/mol creatinine.

The reference interval for blood cobalt is 0.3 – 10.0 nmol/L. Post-arthroplasty patients with blood cobalt levels above 119 nmol/L should be re-evaluated every 6 months [6].

The reference interval for hair cobalt is 0.01 – 0.20 ug/gram of hair .

References

1. Lison D. Cobalt. In: Handbook on the toxicology of the metals, 3rd edition. Eds: Nordberg GF, Fowler BA, Nordberg M, Friberg LT Elsevier, publishers, Amsterdam 2007; pp 511-528.
2. Brewer G. A statistical study of cobalt polycythemia in the dog. *Am J Physiol* 1940;128:345-348.
3. Duckham JM, Lee HA. The treatment of refractory anaemia of chronic renal failure with cobalt chloride. *Q J Med* 1976;178:277-294.
4. Morin Y, Daniel P. Quebec beer-drinkers' cardiomyopathy: etiological considerations. *Can Med Assoc J* 1967;97:926-928.
5. Tower SS. Arthroprosthetic cobaltism: neurological and cardiac manifestations in two patients with metal-on-metal arthroplasty. *J Bone Joint Surg* 2010;92:2847-2851.
6. Medical Device Agency alert (MDA/2010/033) for patients implanted with metal-on-metal replacements.