

## ARSENIC - TRACE ELEMENTS

### Introduction

Atomic mass 75. A metalloid that exists in a number of toxic and non-toxic forms. The toxic forms are the inorganic species  $As^{3+}$  and  $As^{5+}$ , and their partially detoxified metabolites, MMA (monomethylarsine) and DMA (dimethylarsine). Seafood may contain significant amounts of non-toxic forms of arsenic such as arsenobetaine and arsenocholine.

Both organic and inorganic forms of arsenic are used widely in industry as insecticides, herbicides, in glass manufacture, semiconductor manufacture and timber preservation. Arsenic polysulphide sheep dips were used until the early 1980s and this may continue to represent a chemical residue problem.

### Exposure

Chronic occupational exposure to arsenical compounds is usually through inhalation of arsenic-containing vapours or dusts, or through non-work environmental exposures, such as drinking arsenic-contaminated water. The smelting of gold, copper and lead ores cause arsenic to become volatile leading to an air pollution hazard. The clinical effects of chronic toxicity can have an insidious onset and can be difficult to diagnose. In chronic poisoning, the peripheral neurological complaints and skin manifestations are usually more prominent than the gastrointestinal symptoms.

### Absorption

Arsenic absorption from the gastrointestinal tract is related to compound water solubility. Marine organo-arsenicals are readily absorbed and excreted over a period of days. Significant absorption of arsenic aerosols and fumes occurs directly from the lungs.

### Distribution

More than 90% of an injected dose of arsenic is cleared from the blood within a few hours. Circulating arsenic is able to cross the placenta. Target organs include skin, hair, nails, kidney and liver.

### Excretion

Inorganic arsenicals are rapidly methylated and excreted in the urine. Methylated arsenicals are less toxic and more readily excreted relative to inorganic arsenicals.

### Pathology

Acute toxicity: nausea, vomiting, abdominal pain, diarrhoea, garlic odour of the breath, dehydration, hypotension, irregular pulse and cardiac instability, and in severe cases shock, acute respiratory distress syndrome, and sometimes death. In some cases, acute encephalopathy can develop and progress over several days, with delirium, coma and seizures. Renal injury can lead to proteinuria, haematuria and acute tubular necrosis. Acute arsenic poisoning can produce severe gastrointestinal irritation. If the dose is large enough (100 to 200 mg) peripheral circulatory failure is then seen. Neuropathy may follow non-lethal acute exposures. Arsine gas (generated through the action of acids on arsenides) produces devastating intravascular haemolysis.



Chronic arsenic poisoning can produce any of the symptoms mentioned above and weakness, lassitude, hair loss, weight loss, dementia and anaemia. Pigmentation and hyperkeratosis are dermatological signs. Mees lines in all nails in the same position and brown pigmentation around eyelids, nipples, axillae, groin, temple and back characterise the pigmentation changes. Hyperkeratoses are surmounted by small corns (2 to 5 mm) and are found on the palms and soles. Peripheral vascular lesions have been described during exposure to contaminated drinking water. Symmetrical sensorimotor polyneuropathy may be found with chronic exposure. Skin cancers have been found to be associated with prolonged exposure to arsenicals.

### **Monitoring**

Whole blood arsenic may be elevated in acute toxicity, but is elevated for only a short time (~4 hours). Urine arsenic (24 hour or random - as arsenic: creatinine ratio) is the preferred laboratory test as it remains elevated for longer following exposure. The 24 hour collection is more accurate but less convenient. Interpretation of the urine total arsenic result provided by most laboratories may be difficult in the presence of a history of seafood consumption. PaLMS Trace Elements Service routinely determines seafood-derived arsenicals where urine total arsenic exceeds the reference range quoted, to assist in the interpretation of results. The concentration of arsenic in hair and nails has been reported to be increased in cases of exposure. The interpretation of results from these samples is always difficult due to the possibility of environmental contamination.

### **Treatment**

Arsine poisoning is managed by support including exchange transfusion and haemodialysis, chelation therapy is not indicated. Support therapy and chelation (dimercaprol or penicillamine) is indicated for acute arsenic poisoning. Chronic arsenic poisoning is managed by removal of the source of exposure and support therapy as required. Chelation is of marginal use.

### **Analysis**

Graphite furnace and hydride generation atomic absorption spectrometry have been used to determine arsenic. PaLMS Trace Elements Service uses inductively coupled plasma mass spectrometry to determine total arsenic in various matrices. Partial speciation of urine arsenic compounds is carried out using selective complexation, extraction and inductively coupled plasma mass spectrometry. Full speciation is carried out using high pressure liquid chromatography separation coupled to inductively coupled plasma mass spectrometry detection.

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