Boron

Atomic number 5
Atomic weight 10.81

Collection

Serum/Plasma	5 mL	Plastic tube. Trace Element tube
Blood	5 mL	EDTA anticoagulant. Trace Element tube
Urine	20 mL	Sterile Universal

Reference ranges

			Reference
Serum/plasma	µmol/L	1.8 – 7.3	1
Blood	µmol/L	1.3 – 4.1	1
Urine	µmol/24 h	59.9-434	2
	µmol/mmol creatinine	5.1-38.5	2
	mmol/mol creatinine	Male 24.0 (95th percentile) Female 30.9 (95th percentile)	3
Hair	µmol/L/g	0.02 – 0.17	1

References

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Clinical

Boron belongs to group III of the periodic table. It has two isotopes ^{11}B (80.2%) and ^{10}B (19.8%). The element is ubiquitous in the environment and may be found in the form of borates in varying amounts in rocks, soil and water supplies. Boron containing compounds have been known for many hundreds, possibly thousands of years, particularly, borax (sodium tetraborate decahydrate) which is thought to have been used as a flux for working Gold by the ancient Babylonians. Boron forms compounds with a number of elements including oxygen, hydrogen, nitrogen and carbon. The best known compound of boron is boric acid (H_3BO_3; orthoboric acid), which is very water soluble and possesses bacteriostatic and fungistatic properties. Historically it has been used in some cosmetics and toiletries. Boric acid is also used as a preservative for urine specimens requiring bacteriological examination.

Boron, because of its extensive distribution in the environment, is a normal component of the diet.

Dietary intake in the UK has been estimated to be about 1.4 mg/day, which includes a contribution of 0.2–0.6 mg/day from drinking water. Relatively high concentrations of boron are found in green vegetables, fresh fruit, nuts, raisins and wine. Nutritional surveys, however, have shown that boron intake by vegetarians may actually be relatively low due to consumption of larger quantities of low-boron grain products. Extensive consumption of coffee and milk are also important sources of boron in the diet, particularly in the US. Multi-vitamin and mineral supplements may contain between 1.5 – 10 mg of boron per dose.

Major industrial uses of boron-containing compounds include glass and ceramics *e.g.,* fibreglass, control rods for nuclear reactors, detergents, bleaches, alloys and fluxes, fire retardants. More recently isotopically ^{10}B enriched boron containing drugs such as boron phenylalanine (BPA) have found application in Boron Neutron Capture Therapy (BNCT) for the treatment of malignant brain tumours. In BNCT, the ^{10}B-containing drugs are selectively taken up by tumour cells prior to the tumour area being radiated with epithermal neutrons. ^{10}B capture of the thermal neutrons then induces secondary radiation within the cancer cells, selectively destroying them. The duration and timing of the irradiation may be adjusted by monitoring ^{10}B in whole blood.

The essentiality of boron for plants is well established, and borates are widely used in fertilizers for improving fields of certain crops susceptible to boron deficiency *e.g.,* apples, sugar beet. The essential role of boron in animal health, including humans, is less well understood, but increasingly recognised by many researchers and expert committees. It is thought that boron may be involved in the metabolism and utilization of a number of other elements, in particular calcium, as well as glucose, lipids, reactive oxygen and oestrogen. It has been proposed that it may have an important role in bone calcification and maintenance.

Although boron deficiency has not definitely been observed in human populations, there is evidence indicating that boron deficiency in humans may be of clinical significance and it has been suggested that boron deficiency may be a contributing factor to Kashin-Beck disease, which is also linked to selenium deficiency. A number of studies have shown that boron containing supplements (*e.g.,* calcium fructoborate) may be of benefit in the treatment of inflammatory conditions such as arthritis and osteoporosis, particularly in post-menopausal women. There is also some evidence that boron may play a role in regulating immune function, embryonic development, cancer, heart disease and memory function. Although double blind controlled studies are lacking for most indications, there is promotion of boron-containing supplements by the complementary health care sector.

Toxicity

Borates generally have a high oral bioavailability and are excreted unchanged in urine. Ingestion of relatively large doses of boron containing compounds are required to cause signs and symptoms of poisoning with acute lethal doses of boric acid being reported as 3000 – 6000 mg for infants and 15000 – 20000 for adults. Elsewhere, clinical symptoms of boron toxicity have been observed with doses of 100 – 55000 mg/day, with the toxic dose being dependent on age and body weight, while ingestion of boric acid equivalent to 25-76 mg boron/kg/day over a period of days or weeks led to various symptoms, the most common being vomiting, diarrhoea and abdominal pain.

Most reports of boron toxicity are historical cases involving young children and newborn babies, particularly at a time when boric acid was used as a household “antiseptic” and patent remedies containing borax and honey. The main signs and symptoms of poisoning described were gastrointestinal disturbance, irritability and seizures as well as severe erythema (described as “boiled lobster”) exfoliation and desquamation of skin. Extremely high plasma concentrations of borate, often in excess of several hundred mg/L, have been associated with both non-fatal and fatal poisoning.

In animal studies, long term exposure to boron has been reported to decrease male fertility but such an effect in humans in occupationally exposed borax mine workers was not demonstrated. Similarly no effects on fertility were apparent in a Turkish population with high levels of boron in drinking water (up to 29 mg/L).

No adverse effects were found in women supplemented with 3 mg/day of boron for one year although increased plasma oestradiol concentrations were observed in post-menopausal women taking 2.5 mg/day for 3 months. Increased plasma oestradiol and testosterone were noted in male volunteers, supplemented with 10 mg/day. The amount of human data available has been deemed insufficient to derive a tolerable upper intake level for boron but a value of 10 mg/day in adults has been suggested following extrapolation of data from animal studies.

Measurement of boron and indices of boron status

Historical techniques for measurement of boron in biological fluids were based on colorimetric analysis using carminic acid and were generally only suitable for the investigation of suspected poisoning.

Traditional trace element methods of analysis for boron in biological fluids based on electrothermal atomic absorption are relatively unsuccessful, because of the extremely high atomisation temperatures required, and have a poor sensitivity. More recently sensitive techniques for boron measurement have been based on ICP-Mass Spectrometry and separation of boron isotopes has been possible. Recent advances in ICP-MS instrumentation has made it possible to achieve relatively low limits of quantification without the need for sample digestion to remove carbon. However, use of borosilicate glassware may present a source of boron contamination and should therefore be avoided. Only recently have reliable reference values been established for healthy adult populations. There are currently no defined reference data on children or diseased populations (e.g. end stage renal failure) using ICP-MS techniques.

Measurement of isotopically enriched (^{10}B) boron-containing drugs such as mercaptodecaboronate and boron phenylalanine and their metabolites has been carried out using liquid chromatography – mass spectrometry and liquid chromatography linked to ICP-Atomic Emission Spectrometry. Such techniques have been applied to clinical trials of Boron Neutron Capture Therapy, but could be also applied to the analysis of organo-boron compounds and their metabolites.

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