Mercury Toxicity and How it Affects our Health

**Historical Aspects**

Some of the mental and physical effects of chronic exposure to mercury are known to us all, immortalised in Lewis Carroll's Mad Hatter in 'Alice in Wonderland'. Mercury salts were used historically in the manufacture of felt hats and absorption of these compounds through the skin gave rise to body burdens sufficient to cause the symptoms of madness among this profession. Likewise, the use of mercury salts in the 19th Century for the treatment of syphilis gave rise to severe side effects and many deaths.

Mercury toxicity made headline news in this country after the release of waste containing mercuric chloride (a catalyst in the production of plastics) into the bays of Minemata and Niigata, Japan in 1953 and 1960. Methylation of the metal by plankton and its subsequent incorporation into the food chain caused acute toxicity in victims eating fish caught in that region. Although immediate fatalities were apparently limited to 52 persons, hundreds of children and adults have since developed degenerative neurological disorders presenting as paraesthesia, ataxia, dysarthria, hearing and visual loss. In these regions, cerebral palsy too has persisted at a high 6% incidence of births.

In 1972, large quantities of grain treated with methyl mercury fungicide for planting were accidentally distributed to villagers in Iraq. Despite official warnings, much of the grain was ground and made into bread. In the disaster which followed, 6530 people were hospitalised and at least 500 died of mercury poisoning.

**Mercury in Industry**

Mercury poisoning used to be widespread in such industries as mirror making and cinnabar (mercury ore) mining. In Western countries, the use of mercury in industrial processes has almost disappeared. In modern times, exposure, and therefore toxicity is limited mainly to dentistry; thermometer, barometer and mercury arc equipment manufacture; pigment, fungicide, insecticide and dry cell battery manufacture. Mercury compounds have in the past been used as diuretics, anti-infectives, laxatives, eye and skin treatments, but these uses have now been superseded by more appropriate drugs.

Disposal of mercury-containing domestic batteries on council dumps poses an enormous ecological problem; however this does help to put the dental use of mercury into perspective. It was estimated in the US in 1989 that discarded household batteries accounted for 86% of dumped mercury, while dental amalgam represented just 0.6% and has been declining steadily in quantity over the past three decades.

Mercury compounds were once used extensively in the production of paper and Sweden was found to be dumping enormous quantities of mercury-rich effluent from its paper industry into the sea. Pressure from environmentalists has eradicated mercury use in paper-making for good. Bizarrely, there is also concern about the risk to health of mercury vapour discharged from crematoria as a result of incineration of people with amalgam fillings. Certainly, toxic mercury vapour is measurable in the the air downwind from crematoria when
There is international concern at present over the illegal dumping of thousands of tonnes of mercury every year, used for extraction of gold from ore, in the Brazilian Amazon area. Many hundreds of cases of mercury toxicity have been reported in the area and ecologists are very concerned about health effects once the water table is contaminated. More primitive gold extraction techniques involve boiling off mercury from gold-mercury amalgam in open pots over a fire.

**Mechanisms of Mercury Toxicity**

When you work in an environment contaminated with mercury, you quickly absorb the toxic metal. For example, dentists are exposed to mercury vapour and to mercury-rich amalgam dust; this is the 'fall-out' of aerosols generated during removal of amalgam restorations. Skin exposure to native mercury used to be common in dentistry when amalgams were mixed by hand in a chamois leather, but this practice has almost ceased.

On occupational exposure to mercury, absorption is mainly via the lungs; mercury vapour is absorbed to an extent of between 90 and 100% by this route. Dust and droplets on the skin and in the gut are absorbed to a minor extent (about 15%) but doses to these regions are often high.

Some biotransformation of inorganic mercury to short-chain alkyl (methyl and ethyl) forms occurs in micro-organisms in the mouth and in the gut; absorption of these organic forms is relatively efficient (80 to 100%); these are the same chemicals which wreaked so much human devastation in Minemata. Distribution of absorbed mercury throughout the body readily occurs via the blood and mercury partitions reversibly into all organs, including the brain and nerve tissue, which have a higher affinity for the organic forms.

Whilst the half-life of mercury in the blood has been estimated as about 3 days, mercury in body tissues clears slowly, with a half-life of about 90 days. So cessation of exposure will not therefore have immediately beneficial results, in the event of mercury poisoning - benefits of ceasing exposure will only be seen after about a year - four half-lives.

Both inorganic and organic mercury compounds have an avid affinity for thiol (-SH) chemical groups and this is the property which renders them toxic. Most proteins, and all enzymes, contain these thiol groups; this explains both the binding of mercury to all body tissues and many of the biological effects. Most mercury compounds are potent but unspecific enzyme inhibitors, affecting membrane permeability and hence nerve conduction and tissue respiration. In this respect, the biochemical effects of mercury resemble those of black widow spider venom.

**How the Body Gets Rid of Mercury**

Disposal of the body’s burden of mercury is via the urine and faeces, although minute amounts are detectable in expired air. Excretion via the liver occurs in bile and reabsorption of some of this mercury does take place. However, the kidney is equipped with an efficient, energy-dependant mechanism for disposing of metals such as mercury.

Kidney tissue contains a thiol-rich protein called metallothionein; exposure to toxic metals triggers the production of this protein which binds tightly to the metal, retaining it in the kidney tissue in a relatively harmless form. As long as the kidney's capacity for production of metallothionein is not overwhelmed, mercury excretion can eventually balance intake, thereby limiting worsening of symptoms. However, acute high doses of mercury, or an increase in the chronic dose level can readily precipitate renal failure, one of the classic symptoms of mercury poisoning.

A small proportion of total body mercury is excreted in various forms directly in the urine without being bound to protein. In low dose, steady state conditions, such as the dentist who has worked at a similar exposure level for years, the urinary output very accurately reflects the total body burden and this is why urine monitoring is so important.
Clinical Symptoms of Mercury Toxicity

Symptoms Characteristic of Chronic, Low-Dose Exposure

- Erefthism (nervousness, irritability, mood instability, blushing)
- Tremor
- Personality change
- Suicidal tendency
- Paraesthesia
- Impaired hearing
- Speech disorders
- Visual disturbance
- Abnormal reflexes
- Disturbed gait
- Gingivitis (inflammation of the gums)
- Impaired nerve conduction
- Renal damage
- Adverse outcome of pregnancy
- Infertility
- Pneumonitis (lung disease)
- Glioblastoma (brain cancer)
- Immune system dysfunction

Symptoms Characteristic of Acute, High-Dose Exposure

- Gastroenteritis (stomach upset)
- Mouth pain
- Abdominal pain
- Vomiting
- Excessive salivation
- Anuria (urine production stops)
- Uraemia (urine products appearing in the blood)
- Nephritis (kidney disease leading to kidney failure)
- Anorexia (lack of appetite)
- Ataxia (difficulty in moving)

Mercury and Reproductive Health

Chronic mercury exposure can seriously impair fertility and outcome of pregnancy. In one study, 45 women dentists and 31 dental nurses were questioned about their reproductive history and hair samples were taken to estimate mercury exposure. A positive association was found between elevated mercury levels and incidence of malformations and aborted pregnancies. Mercury exposure also resulted in menstrual cycle disorders, arising from interference with the part of the brain which controls reproduction (hypothalamo-pituitary-gonadal axis).
During pregnancy, mercury passes readily through the placenta; the concentration in cord blood is elevated above the level of the maternal blood. There is therefore a risk to the foetus in chronically-exposed pregnant women, although case studies to date are not conclusive. One case report describes the birth of a severely brain-damaged baby to a woman dentist who was exposed to mercury vapour levels in excess of the TLV during pregnancy. In the most recent report, a Swedish dentist was exposed to mercury vapour during her pregnancy through a leaking amalgamator; the foetus showed mild kidney inflammation but was born clinically healthy. The World Health Organisation stated in 1991 that 'the exposure of women in child-bearing age should be as low as possible'.

In men, organic forms of mercury were found to cause hypospermia, a reduction in libido and impotence in some subjects. Evidence of minor genetic damage (aneuploidy) was found, thought to be caused by interference of the metal with thiol groups in the spindle apparatus of dividing cells. More recently, an adverse effect of mercury on sperm motility was reported and another report describes an increased rate of spontaneous abortion in women whose partners were occupationally exposed to mercury vapour.