Chapter 2
Research of Internal Temperature Distribution for Liver Tissues Under Laser Irradiation

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Abstract Exposure to lead causes a number of diseases, including mild mental retardation resulting from loss of IQ points, as well as increased blood pressure, gastrointestinal effects. Several other disease outcomes have been associated with exposure to lead, but evidence is considered insufficient at this time for a quantitative assessment of their impact on health to be made here. Lead, due to its multiplicity of uses (e.g. leaded petrol, lead in paints, ceramics, food cans, make-up, traditional remedies, batteries), is present in air, dust, soil and water to varying degrees. Each of these media can act as a route of human exposure, through ingestion or inhalation and, to a small degree for organic lead compounds, dermal absorption. Human exposure can be assessed directly, through body burden measurements (lead in blood, teeth or bone) or indirectly, by measuring levels of lead in the environment (air, dust, food or water).

Keywords Lead • Exposure • Human • Health risk

2.1 Lead Hazards to Human Health

Human exposure and effects of lead in humans were reviewed by the International Panel of Chemical Safety in 1995 [1]. According to the review, in humans, lead can result in a wide range of biological effects depending upon the level and

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duration of exposure. Effects at the subcellular level, as well as effects on the overall functioning of the body, have been noted and range from inhibition of enzymes to the production of marked morphological changes and even death in some cases. Such changes occur over a broad range of doses. Due to developmental, neurological, metabolic and behavioural reasons, children are more vulnerable to the effects of lead exposure than adults.

Human exposure to low levels of environmental lead is inevitable, since lead is ubiquitous and one of the most widely dispersed contaminants. Among the population groups, children are the subpopulation of concern for lead exposure. They are exposed to more lead than adults due to their behaviours such as playing on the floor or outdoors, sucking on objects, and hand- to-mouth activity, which is normal developmental activity. The high gastrointestinal absorption of lead of children also causes higher uptake of lead to the system, which may lead to irreversible damage to a susceptible nervous system during its developing stage. Although classical lead poisoning is a rare occurrence worldwide these days, developmental effects in children caused by low level exposure to lead are well acknowledged.

Human exposure and effects of lead in humans were reviewed by the International Panel of Chemical Safety in 1995 [1]. According to the review, in humans, lead can result in a wide range of biological effects depending upon the level and duration of exposure. Effects at the subcellular level, as well as effects on the overall functioning of the body, have been noted and range from inhibition of enzymes to the production of marked morphological changes and even death in some cases. Such changes occur over a broad range of doses. Due to developmental, neurological, metabolic and behavioural reasons, children are more vulnerable to the effects of lead exposure than adults.

Lead is the most studied metal and knowledge about adverse health effects of lead, especially in high concentration, are well known but the effects of low concentration long term exposure are still under study, especially during the last decade.

Lead binds to the sulphydryl (SH) groups of proteins, but the basic mechanism of the lead toxicity is not yet established. Increasingly more is known about molecular effects of lead. Among other effects lead displaces calcium and zinc inside proteins, has an affinity for cell membrane, interferes with mitochondrial oxidative phosphorylation and impairs activity of calcium dependent intracellular messengers and protein kinas C. Lead may inhibit DNA repair and exert genotoxic effects and affects sodium, potassium and calcium ATP-ase. Therefore the toxic effects of lead may involve several organ systems including: nervous system (central and peripheral), cardiovascular, haem biosynthesis, kidney, reproduction, the immune system, alimentary systems, and hepatic system.

Health effects induced by environmental lead exposure (i.e. at lower doses of lead exposure) are associated with effects on nervous system, effects on heam biosynthesis and effects on blood pressure.

Effects on nervous system—Both cross-sectional and prospective study were focused mostly on neuropsychological development in children and they confirmed that children represent a group being particularly at risk, especially from neurobehavioral effects.

Effects on nervous systems include a constellation of effects like decreases in IQ, poor school performance, problems with impulse control and attention deficits. Meta-analyses of the studies have concluded that doubling Pb–B form 10 to 20 than 10 μg/dL is associated with an average loss of IQ of 1–3 points. The relationship between IQ and lead exposure is very strongly linked even at low level of lead exposure.

More recent studies of Lanphear et al. [2] showed that cognitive deficits are associated with Pb–B concentration below 5 μg/dL. Social and emotional dysfunctions and academic performance deficits are correlated with increased lead exposure. Prospective studies support hypothesis that changes are irreversible or at least long lasting up to adulthood. Different investigators focused on different behaviours e.g. tests of fine motor skills, language, memory and learning, attention, and executive functioning, so that no investigation assessed a complete spectrum of neuropsychological functions.

A recent study of Nevin [3] demonstrates that (besides reduction in IQ) widespread exposure to lead is likely to have profound implications for a wide array of undesirable social behaviour. The neurotoxicity of lead is of particular concern, because evidence from prospective longitudinal studies has shown that neurobehavioral effects, such as impaired academic performance and deficits in motor skills, may persist even after Pb–B levels have returned to normal. Although no threshold level for these effects has been established, the available evidence suggests that lead toxicity may occur at B–Pb levels of 10–15 μg/dL or possibly less [4].

Effects on blood pressure—Effects of lead on blood pressure and kidney are evident at high concentration in occupational settings and animal studies, but less evident in the general population. There are a few studies on general population dealing with effects of lead on blood pressure. Rothenberg et al. (2002) examined effects of blood and bone lead on blood pressure between 1995 and 2001. They found out that in normotensive pregnant women each 10 μg/dL increase in calcaneus bone lead was associated with a 0.70 mm-Hg increase in third trimester systolic blood pressure and 0.54 mm-Hg increase in diastolic blood pressure. The NHANES III study showed similar results. Effects of lead on blood pressure at higher levels were confirmed by animal studies.

Cancer—The evidence for carcinogenicity of lead and several inorganic lead compounds in humans is inconclusive. Classification of IARC is class 2B: 'The agent (mixture) is possibly carcinogenic to humans. The exposure circumstance entails exposures that are possibly carcinogenic to humans' [5]. The US Department of Health and Human Services has determined that lead and lead compounds are reasonably anticipated to be human carcinogens based on limited evidence from studies in humans and sufficient evidence from animal studies, and the US EPA has determined that lead is a probable human carcinogen.

2.2 Human Exposure

2.2.1 Lead in the Diet

The daily intakes vary by country, nd the sources of lead will wary with the diet. In the EU, fruits and vegetables, cereals and bakery wares and beverages are major sources of lead, together supplying most of the intake [6]. In Japan, the daily intake of lead per person in the year 2004 is estimated at 26.8 μg Pb/person/day [7]. The main contribution came from rice (25 %), other vegetables and seaweeds (20 %), seasonigs and bewerages (18 %) and fish and shellfish (4 %) [7]. The average dietary lead intake of an adult Finnish person is estimated to be 17 μg Pb/day. The sources of dietary lead intake in the Finnish population are fish and canned fish (23 % of total dietary lead intake), root crops, vegetables, fruits and berries (17 %), grain and grain products (15 %), juices and other drinks (12 %), milk and milk products (11 %), meat and meat products (9 %), alcohol (7 %) and other food sources (6 %).

2.2.2 Ingestion of Soil and Dust

For infants and young children, lead in dust and soil often constitutes a major exposure pathway and this has been one of the main concerns regarding the exposure of the general population. The intake of lead is influenced by the age and behavioural characteristics of the child and the bioavailability of lead in the source material. Dust (in homes as well as in streets) and soil may contain high lead concentrations and are significant sources of exposure of children. In particular, dust in homes painted with paint containing lead pigment, and soil around lead-emitting industries may contain very high lead levels. The maximum uptake in infants seems to occur around 2 years of age, and is higher in the summer than in the winter. The hand-to-mouth behaviour of children is important for lead intake [2], and even small babies, unable of grasping objects, receive much of their lead exposure from mouthing their own fingers.

2.2.3 Lead Intake via Inhalation of Ambient Air

Airborne lead may contribute significantly to exposure, depending upon factors such as use of tobacco, occupation, proximity to motorways, lead smelters, etc., and leisure activities (e.g., arts and crafts, firearm target practice). In countries where leaded gasoline is still used, inhalation of emissions is a major lead exposure pathway. In particular proximity to heavily trafficked roads may influence airborne lead exposure.

2.2.4 Lead Intake via Drinking Water

With distribution of drinking water, the water may be contaminated with lead from lead pipes, lead-soldered copper-pipes, lead-containing brass-joints for plastic pipes, or from other parts of the water system. In particular, acidic and soft water has the potential for dissolving lead. The level is then dependent upon the time during which the water did dwell in the pipe. The lead content of drinking water may vary considerably. Hence, intakes of about 1 μg/day or less have been reported from Sweden, whereas a study in Hamburg, Germany, in an area where lead pipes are common in old plumbing systems, showed a large variation in the lead concentration in tap water: <5–330 μg/L [8]. Among the samples a mean of 15 μg/L was found. High concentrations of lead in tap water are of special concern for bottle-fed babies when formula feeding is prepared from the tap water.

2.3 Reference Levels

Provisional tolerable weekly intake—The joint FAO/WHO Expert Committee on Food Additives has established a provisional tolerable weekly intake (PTWI) of 25 μg/kg body weight (equivalent to 3.5 μg/kg of body weight per day) [9]. The Committee considered the results of a quantitative risk assessment and concluded that the concentrations of lead found currently in food would have negligible effects on the neurobehavioural development of infants and children. The Committee noted, however, that examples of foods with high levels of lead remain in commerce.

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