

Original Article

Lead Toxicity in Children: A Public Health Issue

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Abstract

Lead poisoning, also known as plumbism is a type of heavy metal poisoning caused by the exposure to lead metal and the excessive absorption of the metal particles into the blood circulation. Lead poisoning can also be recognized as a major public health concern. The US Centers for Disease Control and Prevention and the World Health Organization stated that a blood lead level of 10 µg/dL or above is a cause for concern. There are many undeniable evidence that associate lead at different exposure levels with a wide range of health and social effects, including mild intellectual impairment, hyperactivity, shortened concentration span, poor academic performance by students in early stages of learning, aggressive behavior, and hearing impairment. Lead has an impact on major organ systems, including the heart, liver, brain, kidneys, and the circulatory system, eventually in severe cases may lead to coma and death. The removal of lead from the child's environment is the first line treatment and after determining the blood lead level chelation therapy can be administered. It's up to health professionals and decision-makers to look in depth on the serious impact of lead heavy metal on the well being and health of children in our community.

Keywords: lead (pb), blood lead level BLL, neurotoxicity, chelation therapy.

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Introduction

Lead poisoning, also known as plumbism is a type of heavy metal poisoning caused by the exposure to lead metal and the excessive absorption and accumulation of the metal particles into the blood circulation. Lead has no biologic purpose in the body, and any detectable level in the physiological system is considered abnormal and an indication for the exposure to environmental lead contamination.[1]

Throughout history through constant research done into childhood lead

poisoning it has been established as an important public health concern. In children, low to moderate elevated blood lead levels (BLLs) are associated with decreased IQ levels and difficulty paying attention in classrooms in schools learning difficulties such as dyslexia resulting in poor academic achievements in those affected students, and it can also have a negative impact on child tutoring at home as a parent may be concerned over their child's future academic achievements. [2,3]

In a statement published by the US Centers for Disease Control and Prevention and the World Health Organization blood lead level of 10 µg/dL or above are considered a matter of concern; however, lead may impair development and have negative health effects even at lower levels, and there is no risk free exposure levels.(4,5) The American Academy of Pediatrics defined those levels above 10 µg/dL found in blood samples are labeled as case of lead poisoning in children.(6)On the other hand In 2012, the Centers for Disease Control and Prevention (CDC) Advisory Committee on Childhood Lead Poisoning Prevention recommended that the blood lead level to trigger further investigation and case management be based on the 97.5 percentile of the previous two National Health and Nutrition Examination Surveys (NHANES) blood lead level distributions in one- to five-year-olds. Since 2012, that value has been 5 µg per dL.(7) After the regulations on the ban of leaded gasoline and control measures on

Sources Of Lead

Most children with elevated BLLs today are contaminated through exposure to lead laden dust and paint flakes from deteriorating lead paint on interior surfaces of walls in houses. Most children especially toddlers have a tendency of scraping paint chips from the walls with their fingers and ingesting them, leading to accumulation of lead in the body with time and may go unnoticed.(15) Contaminated soil with lead metal resulting from either mining or lead gasoline can be ingested by children playing in the outdoor environment. Remainder lead deposited in soil from airborne emissions during nearby

the manufacture of commercial products such as paint by the removal of lead in these materials , has shown a significant decrease in BLLs in children in both the U.S and Europe.(8,9,10,11) This shows how the rest of the world should undergo similar regulations by reducing lead levels in all imported goods and local manufacture of all sorts of hardware. Lead exposure continues to be a public health problem in developing countries due to poor governmental regulations on the control of lead metal in the industry and the environment. (12)

A report released by UNICEF and Pure Earth on July 30, 2020 showed that one in three children an estimate of up to 800 million worldwide are affected by lead poisoning.(13,14)

This review will discuss the possible sources of lead metal exposure in children, its health hazards and medical management of children with various levels of lead in their blood circulation.

industrial operations, such as around smelters, remains a hazard even decades after the lockdown of those industrial plants.(16) Tetra-alkyl organic lead compounds such as tetraethyl lead and tetramethyl lead are incorporated into gasoline as anti-knock additives are also a source of inhalational exposure. (17)Toys painted with lead based paint or plastic toys may have lead added as a softer with wear and tear can enter into digestive system as most children put objects in mouth.Children's PVC toys existing in different countries in the world, some of the reviewed articles have revealed substantial levels of lead in these two items far above the permitted limits.(18)Some toy jewelry is made of

lead; a child who ingested a lead charm died of lead poisoning in 2006.(19,20)lead is also found in some folk remedies and ayurvedic drug remedies used in various home remedies in treatment of different ailments. A study conducted on Henna the traditional skin decorations used in locally and most Middle Eastern countries shows different levels of lead in these products which can be absorbed via the skin can be another source of the heavy metal exposure.(21)Lead is found in cosmetic products such as kohl. (22)Traditionally many mothers use kohl on the new born babies for either medicinal or decorative purposes this can pose as an issue as lead

Toxicology Of Lead

The main route of exposure to lead occurs through respiratory and gastrointestinal (GI) tracts. An approximate of 30 – 40 percent the inhaled lead is absorbed into the blood circulation.(25) Respiratory tract absorption is more common in case of industrial poisoning via the inhalation of lead dusts through the lungs.

Nutritional status and age can affect the absorption of lead through the gastrointestinal tract. Some minerals can impair lead uptake in the gut such as iron or calcium that may have been consumed through food or dietary supplements. Iron and calcium reduce lead levels as they decrease its absorption into the blood stream. Children with iron deficiency have high concentrations of lead in their blood.(26)Anemia due to glucose-6-phosphate dehydrogenase (G6PD) deficiency is also known to increase the susceptibility to lead toxicity.(27)In addition lead metal exposure may

can be absorbed into the blood stream through the ocular mucosa.

Water is an often overlooked source of lead contamination, although the source of potable drinking water may not be contaminated with lead from the treatment facilities or wells but may be exposed during transportation.(23) a well known example is the flint, Michigan USA crisis of lead contaminated tap water consumed by residents of the city showing significantly high BLL in children.(24)Moreover fruits and vegetable grown in soil contaminated by lead dust can be another source of ingestion of the metal.

increase erythrocyte fragility and a decrease in red blood cell life span which is another cause of anemia. Basophilic stippling will show in peripheral blood smears as lead causes an inhibition of enzyme 3,5 –pyrimidine nucleotidase.

Once lead is absorbed from both the gastrointestinal and respiratory tract 99% of the metal circulating into the blood stream is bound to erythrocytes (red blood cells) while 1% is present in the plasma.(28) Lead is subsequently distributed to soft tissues such as the brain, bone marrow, aorta, spleen, teeth, liver, kidneys, muscles and gonads.

The primary site of storage of lead in the body after its accumulation is in the bones.(29) During infancy and childhood, lead is deposited in trabecular bone because it is the most active site of remodeling.(30) This implication can hinder the growth and development of stature in children as it may impact elongation of skeletal bones.

Approximately 2/3 of inorganic lead is excreted via the urine while the other 1/3 is expelled in the bile into intestine and removed from the body in the feces. The

Blood Lead Levels

The main method used in the diagnosis of lead poisoning is by the laboratory analysis of the blood lead level (BLL) this

remainder amounts of lead are secreted in sweat and saliva or accumulate into hair and nails.(31)

test is only an indication of the how much lead is circulating into the blood stream without showing the amount of lead metal stored in the body. (32)

Table 1 Summary of children’s health effects by blood lead level.

| Blood lead level µg/dL | Health effects |
|------------------------|--|
| Below 5 µg/dL | <ul style="list-style-type: none"> - decreases in IQ levels - attention deficit disorder with behavioral problems |
| 5–10 µg/dL | <ul style="list-style-type: none"> -Nervous System Effects: decreased auditory function attention deficit disorders (ADD) - Reproductive and Developmental Effects: reduced postnatal growth, delayed puberty for girls and boys |
| 10–44 µg/dL | <ul style="list-style-type: none"> - poor attention and behavioral and emotional problems - decreased hemoglobin and erythrocyte count presenting in iron deficiency anemia |
| 45–69 µg/dL | Severe GIT disturbances such as abdominal pain, constipation, anorexia, nausea and vomiting |
| Above 70 µg/dL | Severe nervous system effects presenting in cases of convulsions loss of voluntary muscle control and eventually coma and death |

Nuerotoxicity

Lead has the ability to produce metabolic and infrastructural disturbances at the molecular and cellular levels of the immature nervous system of children. (33) children are more susceptible to adverse neurodevelopmental effects of lead neurotoxicity than that in adults, due to the vulnerability of their developing nervous system, the postnatal continuation of nervous system maturation, and the increased permeability of neuronal structures to leads entry after exposure to certain levels of lead. (34)

The nuerotoxic effect of lead is because it produces a competitive agonistic effect of calcium.(35) lead competes for binding sites in the cerebellum for phosphokinase C, affecting calcium entrance into cells and neuronal function altering mitochondrial structure, which in turn will lead to an inhibition of cellular respiration and an alteration of calcium-based reaction and neuronal signaling.(36) This process results in an increase in spontaneous neurotransmitter release and an inhibition of what should eventually be known as controlled stimulated release.(35) Immature astroglial cells lack lead-binding proteins which in mature astroglia can be sequestered and eliminated. Lead interferes with myelin formation, both of which are involved in the formation of the blood-brain barrier (BBB). The BBB is not

fully developed until the age of six months, leading to the disruption in the maturation of the blood-brain barrier. The interruption of the barrier results in edema, increased intracranial pressure and encephalopathy due to the infiltration of molecular proteins such as albumin into CNS tissues. (37)

A meta-analysis of four key studies on lead and children's behavior concluded that lead can cause impaired neurobehavioral activity at a BLL of 10 $\mu\text{g}/\text{dL}$. (38) Neurological consequences include cognitive damages such as decrease in auditory functions, impaired visual effects, delayed speech acquirement, learning disabilities, dyslexia and poor arithmetic skills, poor attention and other educational, behavioral, and emotional problems, which can remain into adolescence and adulthood of the child.

Several ongoing studies has shown the relationship between autism spectrum disorder ASD and lead metal exposure. (39,40) children with ASD have shown significantly higher BLL than normal children. It is common in children with autism spectrum disorder and other neurological syndromes have persistent pica behaviors (putting objects in their mouths) are at higher risk for ingestion of lead picked up from toys and other surrounding objects.

Treatment

The first line of management is identifying the source of exposure and removing the child from further contact with the metal. Medical treatment of lead poisoning is relatively straightforward.(41)

Once the BLL of the child has been determined the first line of treatment would be the correction of iron deficiency and the maintenance of an adequate calcium intake, with frequent testing of child to ensure the decrease in blood lead levels.(42)

In case of high blood lead levels exceeding 45µg/dl chelation therapy is recommended. Chelation therapy is preferred to done in a hospital setting by a physician who has proficiency with chelating therapy experience in the management of childhood poisoning. To ensure adequate urine output intravenous fluids must be administered to permit chelation and elimination of lead from the body. further monitoring of fluid intake

Conclusion

Through the reviewed literature in the manuscript so far, it can be concluded that lead poisoning in children can possess a serious public health issue that can be a preventable social environmental hazard. Raising awareness in our community through the health care system and environmental agencies is of vital importance to bestow them with the knowledge they on this matter, so that they can take determined measures to protect their children from lead poisoning.

and output to detect any early inappropriate antidiuretic hormone secretion.

For asymptomatic children with an average blood lead level of 45 to 65 µg/dl Succimer (dimercaptosuccinic acid) would be the appropriate choice in this case. The dosage recommendation is 10mg/kg or 350 mg/m² three times per day is administered. Calcium disodium edetate (CaNa₂ EDTA) another chelating agent administered via continuous intravenous infusion, with a recommended dose of 35-50mg/kg or 1000-1500mg/m². CaNa₂ EDTA should not be used solely in patients presenting with lead encephalopathy, due its inability to cross the blood-brain barrier it may exacerbate lead encephalopathy. Instead dimercaprol (British anti-Lewisite) which has the capability to cross the blood-brain barrier, should be used in combination with CaNa₂ EDTA. The recommended parenteral dose of dimercaprol is 3-5mg every 4 hours given through deep intramuscular injection. (43)

Programs and policies are needed to prevent exposure of children to toxic levels of lead metal , therefore governing laws must be imposed by banning the use of lead-based paints in households and control of lead content in children's PVC toys by the prevention of the importation of such material is also highly recommended. It's up to health professionals and decision-makers to look in depth on the serious impact of lead heavy metal on the well being and health of children in our community.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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