LEAD AND THE HUMAN BODY

Exposure pathways, Distribution and Health impacts

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Outline

- Lead
- Exposure and Distribution
- Health effects
- Specific populations
- Case study

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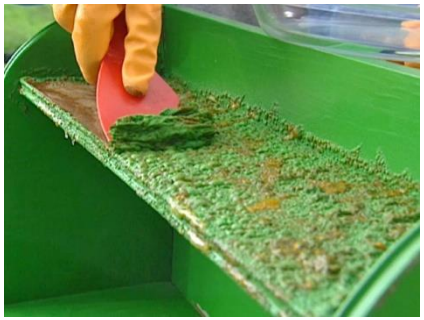
Occupational Sources of Lead

- Paint!
- Batteries
- Pigments
- Lead and ore mining, smelting and refining
- Welding & soldering
- Ammunitions
- Car radiators
- Cable and wires
- ceramics with lead glazes
- Demolition and Waste Handling!

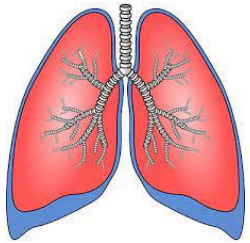
Non-Occupational Sources of Lead

- Lead based paint (especially in poor condition)
- Imported Cosmetics
- Herbal remedies (traditional Chinese medicines)
- Drinking water
- Contamination from nearby lead industry
- Lead sinker making



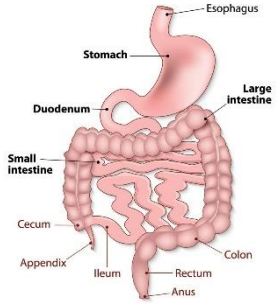
Lead Exposure Pathways

The Respiratory tract



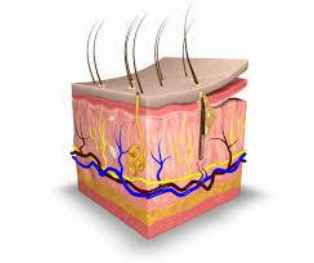
- Highest rate of lead absorption ~ 50%
  - Surface area approx. 70 m^2
  - scraping, sanding, or burning leaded paint and smelting/burning/welding processes that create airborne lead.

The Gastrointestinal (GI) tract



- Lower rate of absorption ~ 10% (children 50%)
  - Surface area approx. 35 m^2
  - May be a major route of absorption for those working or eating in a lead-contaminated environment.
  - Absorption increases during fasting and with diets deficient in calcium, iron, phosphorous, or zinc.

The Skin



- Not a common route of absorption among adults
  - Surface area approx. 2 m^2
  - More common with exposure to organic lead
  - Inorganic lead penetration increased by use of solvents (which reduce the integrity of the skin barrier)

Lead Distribution in the body

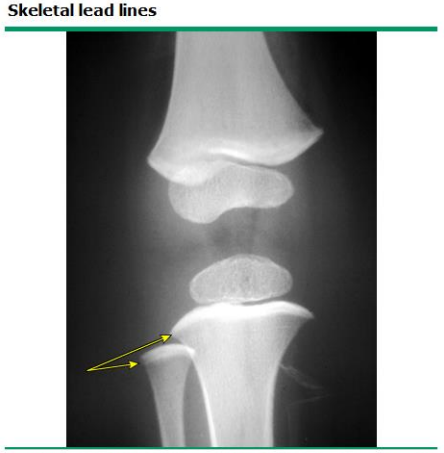
After absorption, lead is distributed to the blood

- While blood is the initial repository of absorbed lead and distributes lead throughout the body
  - It generally carries <5% of the total lead body burden of lead once distributed
- The elimination half-life of lead in adult human blood is approx. 1 month (children up to 10 months).

Lead Distribution in the body cont…

Blood distributed lead to:

- *Soft tissues (~ 5%)*
  - Liver, kidneys and brain have the greatest soft-tissue lead concentrations immediately after acute exposure.
  - Soft tissues elimination half-life of approx. 40 days.
- *Bones (>90%)*
  - Bones and teeth of adults > 90% of their total lead body burden (children contain approximately 75%).
  - Lead accumulation highest in bone regions undergoing the most active calcification at the time of exposure.

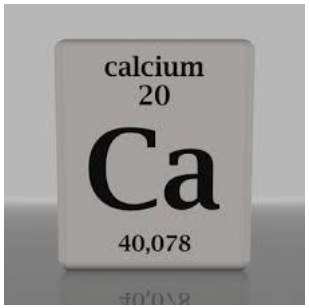


Long-bone radiographs demonstrating lead lines (increased opacity of the proximal tibial and fibular metaphyses, arrows) in a child with chronic lead toxicity.

Courtesy of Richard Hurwitz, MD and Dean A Lee, MD, PhD. UpToDate®

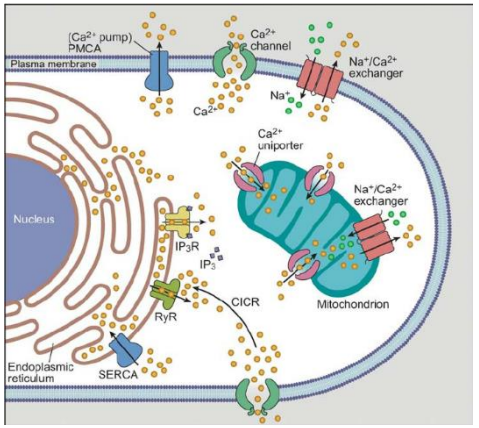
Pathophysiology

- Lead exerts its toxic effect predominantly through it's ability to inhibit or mimic calcium:



- Within bone, lead is incorporated into the mineral in place of calcium.

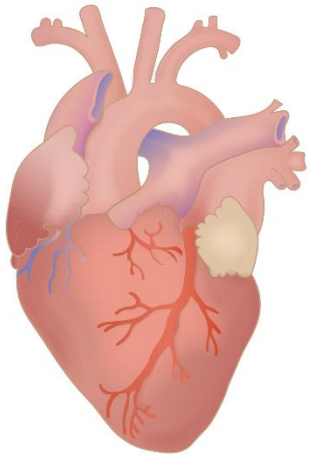
- Lead may also compete with essential calcium and other positively charged ions causing:
  - enzyme inhibition
  - altering crucial cell transport mechanism's for things such as nerve conduction and muscle contractional



Lead competes with calcium

Calcium is one of the most important minerals for the human body.

- Building and maintaining strong bones and teeth
- Clotting blood
- Sending and receiving nerve signals
- Facilitating muscle contraction and relaxation
- Releasing hormones and other chemicals
- Maintaining a normal heartbeat



Acute health effects- Adults

- **Musculoskeletal**
  - Joint pain/arthralgia, muscle ache/myalgia.
- **Neurological**
  - Headache, difficulty concentrating, deficits in short-term memory, irritability, depression.
- **Gastrointestinal**
  - Abdominal pain ("lead colic"), constipation, anorexia.
- **General (hormonal)**
  - Excessive fatigue, sleep disturbance, decreased libido.
- **Hematological effects**
  - Anemia can occur as a subacute effect that usually reflects several months of lead exposures.

Symptoms are most likely to occur	BLL >80 µg/dL
Symptoms are less severe or variable	BLL 40 to 80 µg/dL
Usually asymptomatic	BLL <40 µg/dL

Chronic health effects- Adults

- **Cardiovascular**
  - Cardiovascular disease
  - Hypertension
- **Neurological**
  - Declines in neurocognitive functioning
  - Psychiatric symptoms (phobic anxiety, depression, and hostility)
  - Distal motor and sensorimotor neuropathy after many years of very high exposure
  - Decreases in hearing acuity
  - Tremor
- **Hematological**
  - Anemia
- **Renal**
  - Nephropathy
- **Reproductive**
  - Decreased sperm counts

- Symptoms may occur at blood lead levels <40 µg/dL but over many years of exposure

Chronic Lead exposure after removal from lead work

- Lead can also be released from the bone reservoir into the blood during times of accelerated bone turnover e.g.
  - hyperthyroidism
  - bone fracture
  - Immobilization
  - Menopause
  - pregnancy or
  - breast feeding

Children

Children younger than 6 yo and more so under 3 yo. are more susceptible to the toxic effects of lead:

- "leaky" blood-brain barrier
  - entry of lead into the developing nervous system
- greater prevalence of iron deficiency
  - cause lead poisoning through increased absorption of lead from the gastrointestinal tract
- greater risk of exposure to lead dust because of crawling, higher respiratory rates, and hand-to-mouth behavior.
  - Ingestion of a piece of flaking lead paint the size of a 20 cent piece can be enough to exceed 10 µg/dL.

Abdominal radiograph demonstrates flecks of lead in the pelvis of a child who ingested lead paint chips.
Courtesy of Richard Hurwitz, MD and Dean A Lee, MD, PhD.

Unborn children and neonates

- Lead crosses the placenta readily, and there are NO toxicologic threshold for adverse effects to the fetus or newborn
- Lead exposure during fetal development may result from:
  - mobilization of lead stored in maternal bone into the maternal blood stream
  - from direct elevation of maternal BLLs caused by lead exposure during pregnancy
- Levels of lead in breast milk are up to 3 percent of BLLs in the mother and are directly correlated with maternal blood lead concentration

Health effects- Children

- Central and peripheral nervous systems
  - Decreased IQ and cognitive effects (low levels)
  - Seizures and encephalopathy (high levels)
  - Peripheral neuropathy
  - Hearing loss
- Haematological
  - Anaemia and iron deficiency (rare)
- Renal
  - Lead nephropathy (at levels <10 µg/dL)
- Gastrointestinal
  - Colic, constipation
- Endocrine
  - Disorders of calcium metabolism

Current Australian Guidelines

- Lead risk work is any work that will likely cause blood lead levels of a worker to exceed:
  - 5 µg/dL for females of reproductive capacity
  - 20 µg/dL for all other workers

- This is a reduction from previous blood lead levels of:
  - 10 µg/dL for females of reproductive capacity
  - 30 µg/dL for all other workers

Blood lead levels are required for all workers carrying out Lead Risk Work

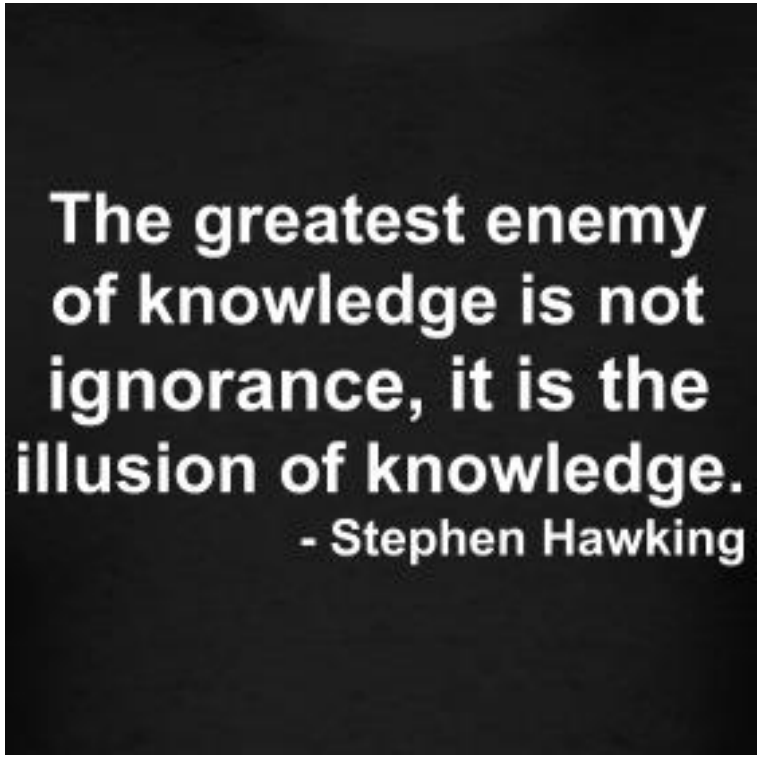
- Blood lead level is a tool to:
  - Identify risk
  - Monitor the effective of controls
  - Improve controls to prevent further exposure

- Blood lead levels should be carried out:
  - before the worker commences the work
  - one month after starting, and
  - at regular intervals depending on previous results, gender and reproductive capacity

Current Guidelines cont…

Action	Blood Lead levels	
	Males and females <u>not</u> of reproductive capacity	**Females of reproductive capacity**
Repeat BLL in 6 mths	<10 µg/dL	-
Repeat BLL in 3 mths	10 to less than 20 µg/dL	<5 µg/dL
Repeat BLL in 6 wks	20 to less than 30 µg/dL	5 to less than 10 µg/dL
Remove from Lead Work	≥ 30 µg/dL	≥ 10 µg/dL
Return to lead work	<20 µg/dL*	< 5 µg/dL*
	* And the medical practitioner is satisfied that the worker is fit to return to work that	* And the medical practitioner is satisfied that the worker is fit to return to work that

Case studies….



Lead Paint removal

- Lead paint removal from an historical building
- Chemical paint stripping
- Reported appropriate PPE including impervious gloves, RPE, disposable overalls
- Reported no eating and drinking and clean area available for breaks
- Reported that facilities for cleaning and decontaminating at end of shift
- Reported all employees trained in hazards associated with lead and precautions required

Blood lead levels

Name	Baseline µg/dl	1 mth µg/dl	Safe Work Levels
MC	0.9	10.8	<10 µg/dl 6mths
RK	1.1	10.9	10-20 µg/dl 3mths
CK	1.3	10.4	20-30 µg/dl 6 weeks
		Workplace controls reviewed	>30 remove from lead work

What do you do next?

Blood lead levels

Name	Baseline µg/dl	1 mth µg/dl	3 mth µg/dl	Safe Work Levels for Men
MC	0.9	10.8	28.3	<10 µg/dl 6mths
RK	1.1	10.9	9.7	10-20 µg/dl 3mths
CK	1.3	10.4	14.5	20-30 µg/dl 6 weeks
				>30 remove from lead work

Do you remove MC from the job?

Lead cont…

- Removed from site after 3 months (blood lead level 28.3 µg/dl)
- Investigation:
  - Fit tested for ½ face negative pressure respirator …BUT… full beard!
  - Smoker (inadequate hand hygiene when smoking between breaks)
  - Sub-optimal cleaning procedures when leaving work area to take breaks
- When can he return to lead risk work?
  - When blood lead level falls below 20 µg/dl
  - When controls have been reviewed and controlled!!

Blood lead levels

Name	Baseline µg/dl	1 mth µg/dl	3 mth µg/dl	2 wks µg/dl	4wks µg/dl	6mth µg/dl
MC	0.9	10.8	28.3	22.7	17.1	8.2
RK	1.1	10.9	9.7	-	-	4.7
CK	1.3	10.4	14.5	-	-	6.2

Removed from work

Returned to work after comprehensive review of work place controls and worker education

Don’t under estimate behaviour as a major contributor to poor health outcomes

- Education is key to engagement of the workforce in controls programs
- Biological monitoring can be a powerful educational tool!

Thank you