

The Medical Aspects of Mercury

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Routes of Exposure

- **Inhalation, ingestion, injection or dermal absorption**
- **Mercury is attracted to SH groups**
 - **poison cellular membranes & enzymes**
- **Symptoms depend on type of exposure, type of Hg, and patient risk group**

Routes of Exposure

- **80% of elemental is absorbed by inhalation.**
- **Accumulates in cortex and cerebellum, then oxidized to Hg^{2+} and it is trapped in the brain.**

Injection of elemental mercury

- Homicide, drug abuse, enhance athletic or sexual performance, self-mutilation, suicide
- IV
 - Embolism
 - Lung deposits, lung and kidney dysfunction, nerve damage, low sperm count
- EKG changes with atrial deposits

Injection of elemental mercury

- **Subcutaneous**
 - Redness, local tissue damage
 - Remote deposits
 - Fat necrosis, granuloma
- **Prompt local excision can prevent toxicity**
- **Often minimal symptoms**

Ingestion of Metallic Mercury

- **Very poor absorption**
- **Low risk**
- **May collect in appendix**
 - re-positioning may be helpful in draining
 - surgery very risky
 - no medical evaluation needed if small amount (thermometer contents)
- **May be aspirated (inhaled into lungs)**
 - Chest x-ray if history of cough/choke/vomiting

Mercury ingestion Case Study

- 28 yr old
- 3 tbsp/day x 12 weeks in traditional Indian medicine
- Urine Hg 26 mcg/L
- Nausea, lethargy, tremor
- Stools with silver droplets
- Sx resolved 8 weeks
- Urine Hg 20.5 at 4 wks
 - 13.8 at 36 wks
 - 3.3 at 2 years

Mercury “ingestion” mishap

- 37 yo female
underwent bariatric
surgery
- Bougie tube stapled to
stomach, released Hg
into peritoneum
- 16 ml in tube
- Blood Hg 38 and 98
(10 days)

Dermal/Topical Mercury

- 59 year old woman presented with tingling, memory loss and episodes of **profuse sweating** after consuming a suspicious “cup of coffee”. Urinary Hg excretion was 151.6 $\mu\text{g}/24 \text{ hr}$ (normal $<10 \mu\text{g}/\text{L}$) and blood Hg was 25.8 $\mu\text{g}/\text{L}$ (normal $<10 \mu\text{g}/\text{L}$). The patient’s home was extensively tested for Hg and abnormal Hg vapor readings were obtained from her personal belongings: underwear: 2.7-32 $\mu\text{g}/\text{m}^3$; washer clothes: 1.7-2.4 $\mu\text{g}/\text{m}^3$; towel: 3.5 $\mu\text{g}/\text{m}^3$. After showering, donning new clothes, and no cosmetics, testing showed zero Hg when passed over patient’s hair, face, neck, axillae, clothes, shoes, or breath. Repeat testing after exercise until perceptible sweating appeared showed: neck: 0.2 $\mu\text{g}/\text{m}^3$; axillae: 0.2 $\mu\text{g}/\text{m}^3$; head/hair: 0.6 $\mu\text{g}/\text{m}^3$; and bagged clothes moist with perspiration: 0.6-4 $\mu\text{g}/\text{m}^3$. The source of Hg exposure was not confirmed, but was suspected to be a **Mexican skin lotion “Crema de Belleza-Manning”**: The patient completed 19 days chelation with DMSA with subsequent urinary Hg of 12 $\mu\text{g}/\text{L}$.
- Other topical products with cases of toxicity: oriental freckle creams, calomel diaper rash ointment
- **These contain mercuric chloride: elemental mercury has no dermal absorption**



Olive Thomas



Inhalation of heated elemental mercury

- Chest tightness
- Lung failure (fatal)
- Fever
- Weakness
- GI upset
- Gum inflammation
- Kidney failure (later)
- Neuropathy (later)

inhalation case report-1810

- **The H.M.S Triumph salvaged a large cargo of elemental mercury from a wrecked Portuguese battleship along the Spanish coast. The drenched leather bags rotted and several tons of mercury were spread through the lower deck. Within 3 weeks, about 200 men developed tremors, mouth ulcers, drooling. Remedies available at the time (sulfur) were not effective.**

Chronic Exposure: Mercury Vapor (toxicity, not hypersensitivity)

- **Personality Changes**
- **Decreased vision/hearing**
- **Peripheral nerve damage (hands, feet)**
- **Hypertension**
- **Kidney damage**

“Mad as a Hatter”

- Fur treated with mercury nitrate to make felt hats
- used since 1840s
- US Public Health Service banned mercury use in 1941
- air concentrations 60 to 720 ug/m³

Mercury Exposure in Children

■ Organic mercury

- Fish consumption (tuna, fish sticks/sandwich)
- in utero exposure

■ Metallic mercury

- broken fever thermometers
- larger amounts in schools & at home
- schools number one site of spills (20%)

Pediatric Mercury Exposures:

- **18,265 mercury thermometer breaks reported to PCC's in 2000**
 - 13,265 in children
 - 12 had moderately severe outcome
- **17,457 thermometer spills in 2001; 9,122 in 2005; 3998 in 2009**
- **15,442 other mercury exposures (2001-5)**
 - 2,307 in children
 - 1 fatality (60 yo heated gold/Hg amalgam)

Inhalation of Mercury Vapor: Pediatric Dose-related “Hypersensitivity”

■ Acrodynia or “Pink’s Disease”

- Traditionally mercuric chloride but recently elemental**
- red palms & soles**
- swelling of hands and feet, pain in extremities**
- itching with peeling of skin**
- hair loss**
- Sweating with “mouse” odor**
- increased HR and BP is a hallmark**
- behavioral changes, muscle weakness, tremor**
- Photophobia (sensitivity to light)**

■ 1 in 500 children; 10% fatality rate

Acrodynia Case Study

A 4 year old Pakistani male presented with 3 mo of diffuse itchy rash, weakness, irritability, red, peeling, tingling hands and feet, excessive sweating requiring multiple baths per day, and significant hypertension (peak-197/140). Evaluation for pheochromocytoma, Kawasaki's disease, scarlet fever, scalded skin syndrome, and heavy metal poisoning was negative and he was discharged with a diagnosis of hypertension. Because his symptoms persisted, he was re-screened for heavy metal exposure and was found to have elevated mercury levels although it was determined that during his hospital stay, he consumed fish sandwiches daily. The health department was notified and found extremely high airborne mercury levels in the home. The parents revealed that a broken thermometer had been discarded in the trash several weeks prior to the first admission. The home underwent remediation and was still > 1500 ng/m³ 8 mo later.

Acrodynia “Pink disease”

What about Fish?

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- **Minamata Bay Incident**
- **Nigigata, Canada, Iraq, Pakistan, Ghana, Guatemala, New Mexico (seeds)**
- **FDA: avoid shark, swordfish, king mackerel, tilefish; more than 1 ppm**
- **EPA: 0.25 ppm**

Tuna has 0.30 ppm (albacore);
0.11 ppm (light).

For 44 lb child, 4.5 oz light or 1.6 oz
white, one sandwich/week

Ingestion of Organic Mercury

- Readily absorbed from the GI tract
- Toxicity may be delayed
 - primarily GI upset, mental status changes, kidney failure, peripheral neuropathy, tremors
- Concentrated in the fetus & breast milk
- Abnormal sperm

- Bottom line: Take a seafood history!!!!



Gotmercury.org

calculator



MERCURY CALCULATOR

1 Your weight: lbs.

2 Fish:

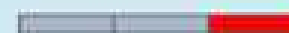
3 Amount you will eat this week: oz.

4

Mercury Exposure:

of EPA Limit *

(Should be under 100%)



Dose: High

Eating Multiple Seafood Types? Use Advanced Mode

Acrodynia Case Report-1990

- A **15 year old** was diagnosed with **measles**, then evaluated for muscle aches, irritability, mental confusion. He was admitted with hypertension, rash, sweating, tremor. Urine mercury was 840 ug/L. His 11 year old sister had mild acrodynia and a urine mercury of 1500 ug/L, which later progressed to peripheral neuropathy. Neither parent had symptoms, despite high levels (820 and 1250). 3 months earlier they had moved into an apartment where **previous tenant spilled a large jar of mercury**. Air levels were 50-400 mcg/m³. After several months of DMSA the boy had mild tremor and the girl could walk short distances.

Acrodynia Case Report-1990

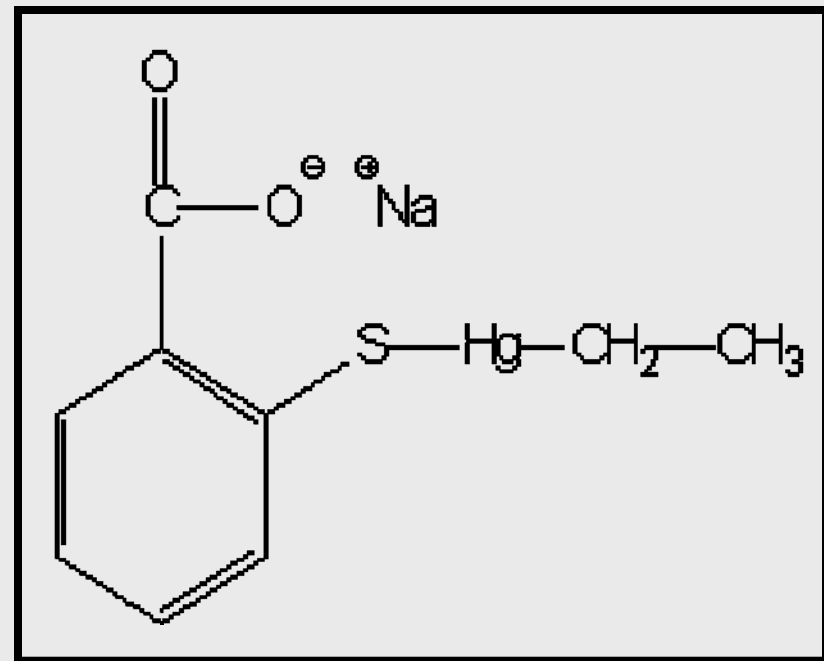
- A **thermometer** broke in a child's room on carpet. **4 months later** the 33-month-old developed loss of appetite, weight loss, light sensitivity, irritability, and pink, sweating, and scaling palms. She presented for treatment **4 months later** with urine Hg 27 ug/L. Her 20-month old sister had eczema and anorexia. The 6 yo brother had eczema and nervousness. All resolved 4 months after chelation.

“We played with it ages ago. Why worry now?”

- **Acrodynia defined in 1950's from calomel but elemental Hg cases only since 1988.**
- **Infants (< 2 yrs) are more susceptible and retain higher percent of absorbed Hg in the brain.**
- **Chronic exposure takes weeks to months**
- **Delay in diagnosis since mimics other illness**
- **All cases involved inadequate clean-up**
- **Decreased air exchanges in newer homes.**
- **Under-reporting is likely since testing is not routine.**
- **Acrodynia affected only 1 in 500 children, is dose-related, depends on form of mercury; we don't know incidence for elemental mercury**

Thimerosal in Vaccines

- Vaccines 0.003 to 0.01%
- thiosalicylate causes delayed hypersensitivity reactions
- acute toxicity described with iv 3 mg/kg from IVIG, HBIG, >100x vaccine dose
- infants received up to 187 mcg during first 6 months
- exceeds EPA guideline of 0.1 mcg/kg/day
- FDA/IOM found no evidence of harm from thimerosal in vaccines
- **No longer in most vaccines!**



In utero organic mercury

- **Organic mercury crosses placenta and BBB**
- **Mental retardation**
- **Developmental delay**
- **Abnormal movements**
- **Seizures**
- **Deafness**
- **Shaking**
- **Hypertension**

Dental Amalgam (Dentist Drills Out Fillings)

- 13 amalgams =
 - 3 ug/day (1/10 of average diet)
- Need 225-265 amalgams to produce toxic urine (10-20 ug/L)
- Air sampling has pitfalls
- 1998, 2007 ADA report says
 - “no worries”

Amalgam Toxicity in Children?

■ DeRouren et al

- 7 year, randomized, controlled longitudinal study
- Children aged 8 – 10 years in Lisbon, Portugal (n = 507)
- Amalgam (n = 253) vs. resin composite (n = 254)
- Results
 - Significant increase in urine mercury levels
 - No significant difference in neurobehavioral outcomes including memory, attention, visual-motor function or nerve conduction velocities

Amalgam Toxicity in Children?

■ Bellinger DC et al

- 5 year randomized, controlled study
- Children aged 6 – 10 years in New England (n = 534)
- Powered to detect a 3 point difference in IQ score
- Results
 - Significant increase in urine mercury levels at 5 years
 - No differences in IQ or Wechsler Intelligence Scale for Children

Documentation of Exposure

■ Workplace OSHA PEL

- $0.05 \text{ mg/m}^3 = 50 \text{ mcg/m}^3 = 50,000 \text{ ng/m}^3$
- results in blood mercury of 30-35 mcg/L
- results in urine mercury of 50 mcg/L

■ Workplace recommendation (ACGIH)

- $0.025 \text{ mg/m}^3 = 25 \text{ mcg/m}^3 = 25,000 \text{ ng/m}^3$
- Lowest adverse effect level = 26 mcg/m³

Non-Occupational Exposure

- **Start with Minimal Risk Level (MRL)**
 - based on occupational lowest adverse effect level of 26 ug/m³
 - average 15 years of exposure
 - adjusted to 24 hour exposure
 - added 30-fold safety factor
 - 0.0002 ug/m³ = 0.2 ug/m³ = 200 ng/m³
- **One thermometer spilled and evaporated**
 - Simulated spills (25 ug/m³ face level; 140 ug/m³ carpet)
 - Examination of past spill (4.5-5.7 ug/m³)
- **The lowest air mercury levels associated with pediatric Acrodynia (2-6 yrs) was 4.2 ug/m³**
- **Correlation of vapor, levels, and time difficult**

What is the true (blood) background level?

- **Lowest level associated with increase in abnormal scores on Boston Naming Test in cord blood was 5.8 ug/L.**
 - Each doubling of blood Hg decreases IQ 1.5 points
- **NHANES 1999-2002**
 - 6% of women had levels > 5.8 ug/L
 - Mean in children 1-5 years: 0.33 ug/L (95% < 2.2)
 - Mean in women childbearing age: 0.92 ug/L
 - Cord blood averages 30-70% higher than maternal blood; 15% had \geq 3.5 ug/L
 - **These numbers are all < lab “normals” of >10**

Diagnosis

■ Blood mercury levels

- Blood is less than 1 mcg/L in unexposed adults and children (NHANES 1999-2002)
- neurotoxicity (tremors) at 10-20 mcg/L
- Neurobehavioral (IQ) at > 5.8 mcg/L in pregnant women
- **reflects recent exposure (days)**

■ Urine mercury levels

- normal < 20 ug/L (in 95% of population)
- neurotoxicity (tremors, abnormal ncv at 20 to 100 ug/L)
- **reflects chronic exposure (4-6 months)**
- No value of chelation challenge test per ACMT position statement

■ Hair analysis not reliable unless for research

■ Breath analysis can confirm re-exposure

Patient sampling after spills

- **Blood mercury provides timely indicator of exposure**
 - 5 of 14 youths playing with large amount had blood mercury ≥ 8 mcg/L on day two
- **Usual half-life in blood is 2-5 days after vapor exposure**
 - Longer half-lives indicate ongoing exposure
 - Selenium sulfide shampoo can decontaminate hair
- **Urine is less reliable after acute vapor exposure**
 - Difficult to obtain 24 hr sample
 - More useful in chronic exposures

Pre-hospital Care

- **Victims of vapor exposure do not pose secondary contamination risk to rescuers.**
- **Skin or clothing visibly contaminated with liquid Hg can contaminate rescuer's equipment, clothing, or indoor environment.**
- **Use positive pressure, SCBA if potentially unsafe levels of Hg**
- **Wear gloves and foot protection since Hg spreads under nails very easily**

Pre-hospital Care

- **Do not induce emesis or give charcoal**
- **Decontaminate victims and rescuer equipment or clothing that has been contaminated.**
- **If ingested, prepare the ambulance in case of vomiting. Have suction available, prepare towels, and double-sealable plastic bags to isolate vomitus.**
- **Do not use ordinary vacuums to clean up transport vehicles.**

Treatment

- **Removal from further exposure**
- **Decontamination**
- **Chelation (drugs that eliminate Hg into urine) on consultation with toxicology**
- **Hemodialysis for renal failure**

- **Indications for chelation are controversial**

Treatment: Chelators

- **Dimercaprol (BAL): intramuscular**
- **DMPS: most effective for organic Hg**
- **Succimer (DMSA): oral**
 - prevents mercury uptake by cells
 - very safe

Treatment

- **May not be effective in reversing toxicity from chronic organic or chronic elemental mercury exposure**



What to tell spill victims?

- If thermometer is cleaned up per instructions, within 24 hours, risk is likely extremely small. Levels are not needed.
- If residual mercury droplets or particles imbedded in carpet remain, the extent of risk is unknown and we cannot predict it.
- Most exposures with confirmed high levels had exposure more than one week.
- If anyone will be affected it will most likely be the youngest (or unborn) child.

Medical Take Home Points

- Mercury is a potent neurotoxin
- Children are more susceptible
- Treatment is not always effective
- Blood mercury levels are most useful if spill is less than one week ago
 - Indicated in children with “playful” exposures
- Lab normals cannot be used to determine acute exposure