Elemental Mercury Toxicity

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Disclaimers

I have no financial conflict of interest in any topic discussed today. The use of succimer in the chelation of mercury is an off-label use, not officially approved by US FDA.

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Learning Objectives

1. Recognize common chemical forms of mercury
2. Recognize common sources of elemental mercury
3. Recognize symptoms attributable to severe elemental mercury toxicity
4. Discuss proper clean-up strategies for mercury releases
5. Discuss the best evidence related to mercury emissions from dental amalgam
Mercury as a Toxin - Background

- FDA estimates daily intake of mercury in food of 3.5 mcg/day
- Different mercury species in the human body are handled differently
  - elemental mercury (Hg⁰) ("quicksilver")
    - absorbed well by inhalation of vapor
    - poorly absorbed to essentially non-absorbed after ingestion
    - converted in vivo to inorganic salts
Mercury as a Toxin - Background

- Inorganic salts (Hg$^{+2}$)
  - poorly absorbed by inhalation, well absorbed PO
  - eliminated renally quickly

- Organic mercury compounds
  - short chain alkyl mercury compounds (MeHg, EtHg)
  - well absorbed PO ($\approx$ 95%)
  - stored in tissue, cross blood-brain barrier well
  - primarily eliminated in feces; some elimination in hair or, after large ingestion, renally
## Assessing the Body Burden of Mercury

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<td><strong>Blood</strong></td>
<td>reflects exposure mainly of recent months</td>
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<tr>
<td><strong>Urine</strong></td>
<td>• reflects exposure mainly of recent days</td>
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<tr>
<td></td>
<td>• poor correlation to neurological tissue burden?</td>
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<tr>
<td><strong>Hair</strong></td>
<td>• no generally accepted method for processing sample</td>
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<td>• large variation between labs</td>
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<td>• uncertain normal values</td>
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<td>• hair / blood ratio varies up to 4x between individuals</td>
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<td>• brain [Hg] in 27 Seychellois infants compared to their mother’s hair at delivery, shown to correlate</td>
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Preferred Tests for Hg Exposure

Blood
- Preferred method to assess MeHg exposure
  - MeHg half life in blood ≈ 45 days
- Limited utility for inorganic Hg
  - Inorganic Hg half life in blood ≈ 3 days

Urine
- Preferred method to assess inorganic Hg
  - Because inorganic Hg primarily renally excreted
Mercury (elemental) - reasons for concern

• Neurotoxicity recognized in adults following intense exposure to elemental mercury vapor
  • Erethrom: depressed and labile affect, memory impairment (particularly short term)
  • Gingivitis
  • Insomnia

• At less intense exposure, may result in impaired performance on neurobehavioral tests (0.014 mg/m³ for > 7 months)
Mercury (elemental) – other acute, high dose effects

- Respiratory distress and pulmonary edema
- Hypertension, tachycardia
- Stomatitis, abdominal pain, nausea/vomiting
- Metal fume fever
- Tremor, muscle spasms
- Acute renal failure, proteinuria

Such exposures often result from heating metallic mercury
Neurotoxicity recognized following exposure to high levels of methyl mercury in utero and in infancy

- in Minamata Bay (industrial discharges -> high methyl mercury in fish)
- in Iraq (consumption of grain intended for seed, treated with an organomercurial fungicide)
- Findings after in-utero exposure: spastic / ataxic gait, dysarthria, deafness, abnormal visual fields, mental retardation
Elemental mercury in personal possession

- Previously acquired material
  - Often found in private residences
- Dental amalgam restorations
- CFLs
- Fluorescent light tubes
Elemental mercury in the community

- CFLs (compact fluorescent lamps)
- Older thermometers
- Older thermostats and silent electrical switches
- Barometers and older sphygmomanometers
- Chemistry labs
- Industrial use: catalyst in chlor-alkali plant
Elemental mercury in schools

- Elemental mercury releases in schools are one of the three most common EPA hazardous material responses.
- Released mercury often creates many tiny beads that roll in multiple directions, lodge in crevices in floor, soak into porous flooring.
- Mercury allowed to remain in/on flooring will gradually evaporate at room temp.
Elemental Mercury Characteristics

- Volatile at room temp and pressure
- Heavier than air, so concentrates near the floor
- Bioavailable by inhalation, so air concentrations after release may pose a toxic hazard
  - Minimally absorbed by ingestion or dermal contact
Toxicokinetics of Elemental Mercury

- OSHA standard: 0.1 mg/m$^3$, 8 hr day
- Absorbed by inhalation or injection
- Penetrates into CNS after conversion to divalent Hg
- In CNS, is converted to inorganic forms which are less mobile between body compartments
- Renal excretion
Dental Amalgam Fillings

- Amalgam is a mixture of metals, including elemental mercury
- Chewing on fillings expresses small amounts of mercury
  - Estimate 1-5 mcg/day from person with 7-10 fillings (DHHS 1993)
  - 12 mcg/day from person with 30 amalgam surfaces repaired (Skare and Engqvist, 1994)
  - Likely lower with older fillings
RCT 1997-2005 of dental restorations in 507 children in Lisbon Portugal aged 8-10yr

5-7 years after repair, no neurobehavioral differences noted on any measure

- Memory, attention, visuomotor, nerve conduction

Resin repairs 50% more likely to need re-repair

- deRouen T et al. *JAMA* 2006; 295:1784-1792
Dental Amalgam - Continued

- Literature review shows no increased risk to adverse health effects from amalgams
- Removal of amalgam filling results in short-term increased mercury exposure during process of removal
  - Rathore M, Singh A, Pant VA. *Toxicol Int* 2012; 19: 81-88
- Recommendation is to NOT remove amalgam fillings to reduce mercury exposure
  - Also restated in the ACMT/AACT “Choosing Wisely” brochure
Dental Amalgam - Continued

- Data are weak regarding possible prenatal / perinatal effects
- Occupational exposure to dental office workers during pregnancy could create risk to fetus
- Some authorities recommend against new placement of amalgam fillings during pregnancy
What about a broken CFL?

- Mercury content varies between brands and models of CFL.
- Classic fluorescent bulbs also contain mercury.
- Amount of elemental mercury released after a fluorescent tube or CFL breaks varies depending on circumstances.
- Expert recommendations vary; State of Maine has done extensive study on CFL breakage.
Broken CFL - Continued

- State of Maine did extensive testing on broken CFL under various circumstances:
  - 45 trials where CFL broken in “small/moderate sized room”
  - Air mercury concentrations sometimes exceeded guidance values at 1 and 5 ft above floor
Cleanup of Broken CFL

- Ventilate room for 15 minutes before attempting cleanup
- Do NOT vacuum; pick up larger pieces with gloved hands
- Use sticky side of duct tape or similar to pick up any other pieces or residue
- Place recovered materials in air-tight container (such as glass jar with metal lid) prior to disposal
- Consider disposing of carpet if area where material was deposited was carpeted
- If carpet not removed, ventilate room when vacuuming for next several times

Cultural Uses

- Various ethnic practices involve the use of elemental mercury
  - “Azogue”
  - May be used in bath water, in topical application, in others
  - Placed on devotional candles to ward off “evil spirits”
  - Potential for spill leading to chronic inhalation
You are called by a school teacher. She has observed a student privately showing off his jar of elemental mercury. The student and 3 others have been playing with it and how it slides across their fingers and glistens and drops to the floor and splatters in a corner of the wood-floored gym before the beginning of lunch.
Your first response is:

1) the released dose is subtoxic, so put the mercury away and don't take it out again till you get home

2) elemental mercury is toxic only by ingestion, so put the mercury away and don't take it out again till you get home

3) the amount likely to have been released is a problem, so confiscate the jar and close off the gym until further analysis

4) the amount likely to have been released is a problem, so confiscate the jar, close the gym and shut off the HVAC system until further analysis
Situation 1: Mercury Release

School child brings a vial (unknown size) of elemental mercury to last day of school
He and friends play with it in school cafeteria/gym, with an unknown amt spilled onto hardwood gym floor
Situation discovered 1.5 hr later
Response to Situation 1

- Site sampling plan created
- Site assessment performed by US EPA Region 4 staff (day 2)
  - Ambient air concentrations vary throughout the area
  - Max level (at any site) was 80 µg/m³
- ACGIH TLV (8 hr TWA) is 25 µg/m³
- OSHA PEL (8 hr TWA) is 50 µg/m³
The Exposure

- Area is closed to the public, list of exposed children obtained
- 22 children, 2 of whom put their hands to their mouths after handling the mercury
- The 2 who put their hands to their mouths report burning lips, resolved; all others asymptomatic
Initial Response

- School officials call fire department
- Fire rescue contains mercury and removes it
- Fire rescue involves city public health officials
- City public health calls state public health and state Environmental Health
ARTICLE

Exposure assessment of a mercury spill in a Nevada school—2004

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Background. Although mercury is toxic, few studies have measured exposure in children who handled elemental mercury briefly. In 2004, a student spilled approximately 60 milliliters of mercury at a Nevada school. Within 12 hours, all students were removed from the source of exposure. We conducted an exposure assessment at the school. Methods. We administered questionnaires and obtained urine samples from students. Using two-sample t-tests, we compared urine mercury levels from students who self-reported exposure to mercury levels of other students. Results. Two-hundred students participated, including 55/62 (89%) who were decontaminated. The students’ geometric mean urine mercury level was 0.36 µg/L (95% confidence interval 0.32–0.40 µg/L). The student who brought the mercury to school was the only one to have an elevated urine mercury level (11.4 µg/L). Conclusion. Despite environmental contamination, mercury exposure may have been minimized because of rapid identification of the elemental mercury spill and decontamination.
Outcome/ PEHSU Response #1

- All remained asymptomatic
- No mercury levels obtained
- Parents reassured by Public Health, in consultation with PEHSU and Poison Center
6 weeks later...

- PEHSU contacted by the perinatal counselor of a pregnant woman who had been in the gym for part of this time
- In retrospect, she was in her first 3 weeks of gestation.
- Effect on the fetus?
- The fetus had no abnormalities by ultrasound at about 10 weeks gestation
PEHSU Response #2

- Given very early stage of gestation, mercury effect would likely have been fetotoxic rather than teratogenic.
- Given apparently healthy fetus at 10 weeks, reassured that there was little added risk over that present in a similar pregnancy without the mercury exposure.
You are called by county public health. Students have been observed playing with elemental mercury on the school bus. The observed event was 2 days ago. The amount estimated to have been released is about 1-2 ounces. What screening of bus riders should be recommended?
Your recommendation is:

1) none needed - they have probably eliminated it all anyway

2) only those with preexisting renal disease need screening, best screening is spot urine mercury

3) only those playing with it need screening, best screening is spot urine mercury

4) everyone on the bus needs screening, best screening is blood mercury
A mother calls you at the poison center. She is concerned that her child with ADHD is suffering from heavy metal poisoning, and has obtained the results of hair and stool samples sent to a commercial lab for heavy metals. Her child has tested "elevated" for mercury, thallium, and zirconium.
You advise:

1. See a medical toxicologist ASAP for chelation
2. These results need further confirmation, obtain 24 hr urine for each through PCP
3. These results are likely to be spurious because of sample collection problems
4. These results are likely to be spurious because of unreliability of hair and stool sampling
The response to “mercury toxicity”

- The finding of “elevated” mercury on various lab tests have led some to recommend succimer chelation to remove the mercury.
- Succimer does remove mercury from blood when it is present at elevated values.
- Succimer does not remove mercury which is bound in tissues.
- Clinical response anecdotally noted in some patients.
Some patients respond to inappropriate therapy

**The study:**
- 50 adult pts who attributed their symptoms to mercury toxicity from amalgam fillings
- placebo-controlled double blind study of succimer x5 days
- urinary excretion of Hg and Pb increased in succimer group
- most pts reported improvement
- no difference in clinical response between placebo and rx

Questions?

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