Case Study

Acute Mercury Intoxication in an Adolescent Male

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AANEM Case Study

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Rochester, MN 55901
EDUCATIONAL OBJECTIVES: Upon completion of this case study, participants will acquire skills to (1) identify the mechanism by which elemental mercury causes toxicity, (2) recognize the clinical features of acrodynia and erethism, (3) identify electrodiagnostic features of peripheral nerve hyperexcitability syndrome, (4) provide details regarding normal levels of mercury in adolescents, and (5) recall the treatment for mercury toxicity.

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AANEM Case Study: Acute Mercury Intoxication in an Adolescent Male
AANEM CASE STUDY
Acute Mercury Intoxication in an Adolescent Male

Joshua Nicholson, DO, Rani Gebara, DO,
Zachary Dyme, MD, and Michael Andary, MD

Presenting symptom(s):
Altered mental status, fatigue, insomnia, tachycardia, desquamating rash, diaphoresis, muscle pain, and diffuse muscle twitches

Case-specific diagnosis:
Mercury neurotoxicity syndrome

Appropriate audience:
Residents, fellows, and practicing physicians

Level of difficulty:
Intermediate

HISTORY I

A previously healthy 12-year-old male is admitted to the pediatric intensive care unit with altered mental status, multiple syncopal episodes, fatigue, insomnia for 1 month, tachycardia, diaphoresis, muscle pain, and diffuse muscle twitching. On the day of admission, the father notes the patient to be very tired, falling in and out of consciousness multiple times despite trying to keep his son awake. The parents report their son has appeared anxious and has not slept well for the last month, both of which have never been problems before. Additionally, for the last month, since returning from a camping trip, the boy has had a red rash on his hands and feet.

Initial pediatric assessment finds the patient to have tachycardia with a heart rate of 150 beats per minute, generalized muscle soreness, diffuse muscle twitching, syncopal episodes, and a desquamating erythematous rash of the palms and soles. Initial workup—including electrocardiogram, computerized tomography of the head, complete blood count with differential, complete metabolic panel, C-reactive protein, erythrocyte sedimentation rate, and urine drug screen—reveals hyponatremia (sodium of 121). Consultations are placed for neurology, cardiology, and psychiatry.

The hyponatremia is corrected with a bolus of 3% saline, followed by a fluid restriction of 1500 ml/day. Further workup includes 24-hour telemetry that reveals persistent sinus tachycardia with a heart rate in the low 100s. Magnetic resonance imaging of the brain is performed and found to
be normal. A 24-hour electroencephalogram is performed and reveals generalized mild slowing consistent with nonspecific encephalopathy. A lumbar puncture is performed, which is found to be within normal limits, including infectious testing for herpes simplex virus, enterovirus, and West Nile virus.

**Questions to Consider**

1. What is your differential diagnosis?

2. Does this initial history provide enough information or is further historical information needed?

**COMMENTARY I**

The initial history describes an adolescent boy with symptoms and signs affecting multiple systems, including neurological, dermatological, psychological, cardiac, and metabolic, resulting in an initial differential diagnosis that may be very large. Yet, when considering the more focal finding of an erythematous desquamating rash on the palm of the hands and sole of the feet in an adolescent patient, the differential diagnoses may be narrowed. An abbreviated list of diagnoses that include rash on the hands and feet may include hand, foot, and mouth disease; meningococcemia; Rocky Mountain spotted fever; Kawasaki disease; measles; toxic shock syndrome; Stevens–Johnson syndrome; syphilis; and mercury toxicity.

**PHYSICAL EXAMINATION**

A general multisystem physical examination with a detailed neurological and musculoskeletal focus follows. A heart rate of 120 beats per minute is found. Manual muscle testing reveals full strength in the upper and lower extremities bilaterally. Muscle stretch reflexes are 3/4 in the upper extremities for the biceps, triceps, and brachioradialis bilaterally. Patellar and Achilles reflexes are 2/4 bilaterally. Plantar reflexes are down going bilaterally. Diffuse muscle tenderness is noted. The patient is observed to have irregular muscle twitching consistent with fasciculations in the upper and lower extremities in multiple muscle groups including the paraspinals.

The patient is found to have an erythematous rash on the hands and feet with desquamation noted in between the fingers and toes. Multiple sites of excoriation of the skin due to scratching are seen. The patient is diaphoretic during the examination. He has two episodes of unresponsiveness that last approximately 10 seconds each.
Questions to Consider

1. In reviewing your differential diagnosis, are revisions necessary?

2. Are there additional observations on the physical examination that might help narrow your differential list?

3. In what conditions are fasciculations observed?

COMMENTARY II

In summary, the physical examination is most remarkable for diaphoresis, tachycardia, diffuse muscle twitching, generalized muscle tenderness, desquamating rash of the hands and feet, and brief unresponsive spells. During the unresponsive spells, the patient goes completely limp but fasciculations continue. It is reported that he does not pull away when his eyes are forcibly opened during the spells. His eyes are noted to roll up without nystagmus in any direction. When he regains consciousness within seconds, he is alert and able to converse appropriately without dysarthria. The examination findings are interpreted as complex and without an obvious single etiology. Further workup is necessary and systemic causes of fasciculations deserve consideration.

HISTORY II

Over the next several days, the boy continues to be symptomatic, having multiple “unresponsive” episodes lasting for seconds each followed by an immediate return of awareness to his circumstances. Additionally, he continues to suffer from muscle pain and twitching. In light of the patient’s recent camping trip, hyponatremia, and hand/foot rash, he is tested for Rocky Mountain spotted fever, which is found to be negative. Further serum testing is negative for human immunodeficiency virus, cytomegalovirus, Epstein–Barr virus, Lyme disease, mycoplasma, tuberculosis, antistreptolysin O titer, antinuclear antibody, anti-neutrophil cytoplasmic antibody, angiotensin converting enzyme antibody, and immunoglobulin G antibody.

Heavy metal serum screening is performed and an elevated mercury level of 13 ng/ml is found (upper limit of normal is 9 ng/ml.) The state department of health and human services toxicology division is contacted and informs the pediatric team that the mercury level is not high enough to be of concern and recommends no treatment as necessary for the “mildly elevated mercury level.” Pediatric neurology evaluates the patient and orders electrodiagnostic (EDX) testing (see Commentary III below for EDX test results).

At this point, the patient is behaviorally acting out toward staff, frequently masturbating, and scratching and picking his skin. Pediatric psychiatry recommends inpatient psychiatric treatment, but the boy’s parents decline inpatient psychiatric admission. The patient’s hyponatremia and tachycardia have resolved. He is believed to be medically stable by the pediatric team and is discharged home with outpatient neurologic, psychiatric, and pediatric followup.
It is not until the boy’s outpatient evaluation with a pediatric endocrinologist that further testing for mercury toxicity is considered. The patient undergoes repeat serum mercury testing, which is elevated at 17 ng/ml. The state department of health and human services toxicology division is contacted again and determines an investigation is now warranted. Screening of the patient’s bedroom and school locker detects mercury vapor levels of >26 mg/m³ in the patient’s backpack. Levels >10 mg/m³ are considered dangerous to health.

Upon further questioning of the boy, he reveals that he has been playing with elemental mercury, which he found and took from his grandfather’s home workshop and kept in his backpack. The boy proceeded to take this backpack camping, where it was stored in his tent and exposed to high temperatures. The high temperatures would have caused the elemental mercury to vaporize, likely exposing the boy during sleep. The boy continued to use the backpack for the proceeding days prior to hospitalization.

**Questions to Consider**

1. How would you revise your differential diagnosis based on the additional clinical history?

2. On which details of the physical examination should you now focus?

**COMMENTARY III**

In retrospect, this seemingly complicated collection of symptoms can be attributed to the single cause of elemental mercury toxicity related to the patient’s multiple acute exposures. Mercury has three forms: metallic elemental mercury, inorganic mercurial salts, and organic mercurials. The adverse health effects of mercury toxicity differ depending on the form of mercury to which the patient is exposed.

Here, the focus is on the health effects associated with elemental mercury toxicity. Elemental mercury is a heavy, shiny, silver, odorless liquid that is minimally volatile at room temperature. However, elemental mercury’s vaporization point is only slightly higher than room temperature, occurring at 77°F (25°C). Mercury vapor inhalation is the primary route of exposure to toxic levels of elemental mercury. Gastrointestinal ingestion of elemental mercury is essentially nontoxic, as it is not absorbed by the gastrointestinal tract. Elemental mercury vapor is odorless and when inhaled is almost completely absorbed by the lungs. The vapor is heavier than air and tends to accumulate in lower areas of confined spaces, such as the bottom of a tent where the boy was known to have slept for several nights during his camping trip.

Although mercury toxicity lacks a specific pathognomonic physical finding, the symptoms associated with elemental mercury toxicity have been grouped into two defined constellations: acrodynia and erethism. Acrodynia, also known as pink disease, is associated with the more acute symptoms of erythema of the palms and soles, desquamating rash, pruritus, diaphoresis, tachycardia, hypertension, mood irritability, and the vague symptom of poor muscle tone. Erethism is marked by the more subacute-to-chronic symptoms of anxiety, insomnia, and behavioral changes, including social withdrawal and hyperexcitability. The patient presented with many of these signs and symptoms, consistent with an acute-to-subacute presentation.
However, the findings of diffuse muscle twitching and episodic unresponsive spells are not included in the classical presentation of acrodynia or erethism.

Needle electromyography (EMG) was ordered due to the discovery of diffuse muscle twitching and generalized muscle soreness. The involuntary spontaneous discharges that were seen on needle EMG were slow irregular single, double, and triple discharges. These discharges were consistent with fasciculations. Other types of spontaneous discharges that are known to have the motor neuron as the generating source include myokymic discharges, cramp potentials, and neuromyotonic discharges, none of which were seen during this patient’s needle EMG.

As a brief review, fasciculations are recognized as irregular, slow firing discharges with a generating source of the motor neuron/axon proximal to the terminal branches. Whereas myokymic discharges are characterized as spontaneous, grouped, rhythmic repetitive discharges firing regularly in a burst like pattern. Additionally, myokymic discharges are thought to have the same motor unit as the generating source. Some of the disorders in which myokymic discharges may be found include radiation plexopathy, Guillain–Barré syndrome, hypocalcemia, timber rattlesnake bites, multiple sclerosis, pontine neoplasms, and radiculopathies. Cramp potentials are recognized as discharges that are usually stable, have a high firing frequency, and have an originating source of the motor axon. Finally, neuromyotonic discharges are recognized as high-frequency and repetitive with a pattern of decreasing amplitude. Neuromyotonic discharges are considered to have the highest firing frequency of all spontaneous discharges, and they are known to have a single motor neuron as the generating source.

### ELECTROPHYSIOLOGIC DATA

Normal values in parentheses.

| Temperature (°C) | Ankles = 26 |

<table>
<thead>
<tr>
<th>NERVE</th>
<th>SIDE</th>
<th>STIM SITE</th>
<th>RECORD</th>
<th>DIST (cm)</th>
<th>AMPL (µV)</th>
<th>PEAK LAT (ms)</th>
<th>CV (m/s)</th>
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<tbody>
<tr>
<td>Sural</td>
<td>Right</td>
<td>Distal leg, laterally</td>
<td>Lateral malleolus</td>
<td>14</td>
<td>35</td>
<td>4.4</td>
<td></td>
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<tr>
<td></td>
<td>Left</td>
<td></td>
<td></td>
<td>14</td>
<td>22</td>
<td>4.4</td>
<td></td>
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Normal values

(≥4) (≤4.5)
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<tr>
<th>NERVE</th>
<th>SIDE</th>
<th>STIM SITE</th>
<th>RECORD</th>
<th>DIST (cm)</th>
<th>AMPL (mV)</th>
<th>ONSET LAT (ms)</th>
<th>CV (m/s)</th>
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<tbody>
<tr>
<td>Tibial</td>
<td>Right</td>
<td>Popliteal fossa ≥ distal medial leg</td>
<td>Abductor hallucis</td>
<td>8</td>
<td>7.8/9.6</td>
<td>5.0</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td></td>
<td></td>
<td>8</td>
<td>9.1/10.9</td>
<td>5.6</td>
<td>41</td>
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<tr>
<td>Normal values</td>
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<td></td>
<td></td>
<td></td>
<td>(≥5.8)</td>
<td>(&lt;6.1)</td>
<td>(≥44)</td>
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<tr>
<td>Tibial H wave</td>
<td>Right</td>
<td>Popliteal fossa</td>
<td>Middle of calf</td>
<td>5.0</td>
<td>32.0</td>
<td></td>
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<td></td>
<td>Left</td>
<td></td>
<td></td>
<td>5.0</td>
<td>33.0</td>
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<tr>
<td>Normal values</td>
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<td></td>
<td></td>
<td></td>
<td>AMPL: Side-to-side comparison of peak-to-peak amplitude difference of &lt;50%</td>
<td>(≤29.8)</td>
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<tr>
<td>Tibial F wave</td>
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<td>Abductor hallucis</td>
<td>8</td>
<td>5.0/5.0</td>
<td>32.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td></td>
<td></td>
<td>8</td>
<td>5.0/5.0</td>
<td>34.0</td>
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<tr>
<td>Normal values</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(≤47.6)</td>
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</table>

Waveforms

**Figure 1.** Right tibial motor nerve conduction study with prolonged aftershocks seen after the compound muscle action potential.
Figure 2. Left tibial F wave nerve conduction study with prolonged aftershocks seen after the F waves.

### Needle Electromyography

- **INSERtional activity:** N, sust, unsust
- **FIB:** 0, 1+, 2+, 3+, 4+
- **FASCiculations**
- **EFFort:** N, decr
- **RECruitmen:** N, inc or dec 1+, 2+, 3+, 4+
- **AMPplitude:** N, inc or dec 1+, 2+, 3+, 4+
- **DURation:** N, inc or dec 1+, 2+, 3+, 4+
- **POLyphasia:** N, inc or dec 1+, 2+, 3+, 4+

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<tr>
<th>R/L</th>
<th>MUSCLE</th>
<th>INSER</th>
<th>FIB</th>
<th>FASC</th>
<th>EFF</th>
<th>REC</th>
<th>AMP</th>
<th>DUR</th>
<th>POLY</th>
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<tbody>
<tr>
<td>R</td>
<td>Rectus femoris</td>
<td>N</td>
<td>0</td>
<td>&gt;200/min</td>
<td>Full</td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Medial gastrocnemius soleus</td>
<td>N</td>
<td>0</td>
<td>&gt;200/min</td>
<td>Full</td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>L</td>
<td>Medial gastrocnemius soleus</td>
<td>N</td>
<td>0</td>
<td>&gt;200/min</td>
<td>Full</td>
<td>N</td>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>Paraspinals T10</td>
<td>N</td>
<td>0</td>
<td>&gt;200/min</td>
<td></td>
<td></td>
<td>N (2K)</td>
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</tbody>
</table>
Waveforms

**Figure 3.** Right medial gastrocnemius soleus: diffuse fasciculations. The bottom waveforms are a closer look at the fasciculations seen in the top trace with a faster sweep speed.

**Figure 4.** Left medial gastrocnemius soleus: fasciculations. The bottom waveforms are a closer look at the fasciculations seen in the top trace with a faster sweep speed.

**Questions to Consider**

1. On the basis of both the clinical and electrophysiologic evaluations, what is your diagnostic impression? List the most likely diagnosis first, followed in order by other possibilities not excluded by the data. Eliminate diagnoses not supported by the data.

2. Are there additional electrophysiologic data that would further delineate the diagnosis?
3. What is nerve hyperexcitability syndrome?

**DIAGNOSTIC IMPRESSION**

EDX testing performed approximately 40 days from the initial exposure to elemental mercury vapors reveal an abnormal study. Motor nerve conduction studies (NCSs) are normal in amplitude, distal latencies, and velocities. Sensory responses are normal in amplitude and latencies. F waves and H waves show prolonged aftershocks. Needle EMG testing is limited by the patient’s tolerance. No fibrillations are seen, and recruitment is normal. Profuse fasciculations and double (doublets) and a few triple (triplets) motor unit discharges are seen. Fasciculations are as frequent as over 200 per minute and are seen in multiple muscle groups including the thoracic paraspinals.

The lack of fibrillations along with normal motor units and recruitment with normal NCS results makes a primary acute neuropathy or myopathy much less likely. The prolonged duration of multiple persistent waves on motor and F wave studies, diffuse fasciculations, and doublet and triplet discharges are suggestive of a peripheral nerve hyperexcitability syndrome. Some of the other conditions in which a peripheral nerve hyperexcitability syndrome is found include neuromyotonia, benign fasciculation syndrome, cramp fasciculation syndrome, and Morvan’s syndrome.

**Questions to Consider**

1. What other diagnostic procedures, if any, are needed?
2. What treatment would you recommend?

**FINAL COMMENTARY**

Fortunately, the patient is started on dimercaptopropane sulphionate chelation therapy with successful resolution of all symptoms over the next 6 months.

Despite the patient having the laboratory value of an elevated serum mercury level and the clinical presentation consistent with both acute toxicity, acrodynia, and subacute-to-chronic poisoning, erethism mercury toxicity was overlooked during the acute hospitalization. This is due partially to the rarity of elemental mercury exposure and partially to the state’s health toxicology department dismissing the initial serum mercury levels as too low to warrant concern.

This case is presented as an educational opportunity to elucidate the clinical presentation of acute-to-subacute elemental mercury toxicity. In addition, these EDX findings are consistent with a peripheral nerve hyperexcitability syndrome that has not, to the authors’ knowledge, been reported in a documented human case of mercury toxicity. Sensorimotor polyneuropathy has been shown to occur with chronic elemental mercury toxicity. However, after reviewing the available literature regarding elemental mercury toxicity and EDX testing, no literature could be found describing acute EDX findings. In conclusion, heavy metal toxicity should be considered in patients with a peripheral nerve hyperexcitability syndrome on EDX testing as this may be a finding of acute elemental mercury toxicity.

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