

Drink the Water, but Don't Eat the Paint

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Although lead poisoning is an uncommon presentation in the ED, the recognition and treatment of a child or adult with occult or overt lead poisoning is essential. This review describes the clinical presentation and management of these patients.

Case

A 2-year-old boy and his mother were referred to the ED by the child's pediatrician after a routine venous blood lead level (BLL) taken at the boy's recent well visit revealed an elevated lead level of 52 mcg/dL (normal range, <5 mcg/dL). The child's mother reported that although her son had always been a picky eater, he had recently been complaining of abdominal pain.

The patient's well-child visits had been normal until his recent 2-year checkup, at which time his pediatrician noticed some speech delay. On further history taking, the emergency physician (EP) learned the patient and his mother resided in an older home (built in the 1950s) that was in disrepair. The mother asked the EP if the elevation in the child's BLL could be due to the drinking water in their town.

What are the most likely sources of environmental lead exposure?

In 2016, the topic of lead poisoning grabbed national attention when a pediatrician in



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Table 1. Signs and Symptoms of Lead Poisoning According to Blood Lead Level and Age⁵

	Signs and Symptoms	Blood Lead Level ^a
Mild	Constipation, anorexia, abdominal pain	<49 mcg/dL (children)
	Irritability	<20-69 mcg/dL (adults)
	Cognitive slowing, intelligence quotient decrement (children)	
	Hypertension, anemia	
Moderate	Worsened anemia	50-70 mcg/dL (children)
	Worsened intellectual deficits, hyperactivity	70-100 mcg/dL (adults)
	Saturnine gout (adults)	
	Peripheral motor neuropathy (adults)	
Severe	Obtundation, seizures, encephalopathy	70-100 mcg/dL (children)
		>100 mcg/dL (adults)

^aHigher blood lead levels are tolerated in adults; symptoms may occur at higher levels.

Flint, Michigan detected an abrupt doubling of the number of children with elevated lead levels in her practice.¹ Upon further investigation, it was discovered that these kids had one thing in common: the source of their drinking water. The City of Flint had recently switched the source of its potable water from Lake Huron to the Flint River. The lower quality water, which was not properly treated with an anticorrosive agent such as orthophosphate, led to widespread pipe corrosion and lead contamination. This finding resulted in a cascade of water testing by other municipalities and school systems, many of which identified lead concentrations above the currently accepted drinking water standard of 15 parts per billion (ppb).

Thousands of children each year are identified to have elevated BLLs, based on the Centers for Disease Control and Prevention definition of a “level of concern” as more than 5 mcg/dL.² The majority of these exposures stem from environmental exposure to lead paint dust in the home, but drinking water normally contributes as a low-level, constant, “basal” exposure. While lead-contaminated drinking water is not acceptable, it is unlikely to generate many ED visits. However, there are a variety of other lead sources that may prompt

children to present to the ED with acute or subacute lead poisoning.

Lead is a heavy metal whose physical properties indicate its common uses. It provides durability and opacity to pigments, which is why it is found in oil paint, house paint used before 1976, and on paint for large outdoor structures, where it is still used. Lead is also found in the pigments used in cosmetics, stained glass, and painted pottery, and as an adulterant in highly colored foodstuffs such as imported turmeric.³

The physicochemical characteristics of lead make it an ideal component of solder. Many plumbing pipes in use today are not lead, but join one another using lead solder at the joints, sites that are vulnerable to corrosion. The heavy molecular weight of lead makes it a useful component of bullets and munitions.

Tetraethyl lead was used as an “anti-knock” agent to smooth out the combustion of heterogenous compounds in automotive fuel before it was removed in the mid-1970s.⁴ Prior to its removal, leaded gasoline was the largest source of air, soil, and groundwater contamination leading to environmental exposures.⁴ At present, the most common source of environmental lead exposure among young children is

through peeling paint in deteriorating residential buildings. Hazardous occupational lead exposures arise from work involving munitions, reclamation and salvage, painting, welding, and numerous other settings—particularly sites where industrial hygiene is suboptimal. Lead from these sites can be inadvertently transported home on clothing or shoes, raising the exposure risk for children in the household.⁴

What are the health effects of lead exposure?

Like most heavy metals, lead is toxic to many organ systems in the body. The signs and symptoms of lead poisoning vary depending on the patient's BLL and age (**Table 1**).⁵ The most common clinical effect of lead in the adult population is hypertension.⁶ Additional renal effects include a Fanconi-type syndrome with glycosuria and proteinuria. Lead can cause a peripheral neuropathy that is predominantly motor, classically causing foot or wrist drop. Abdominal pain from lead exposure is sometimes termed "lead colic" due to its intermittent and often severe nature. Abnormalities in urate metabolism cause a gouty arthritis referred to as "saturnine gout."⁶

The young pediatric central nervous system (CNS) is much more vulnerable to the effects of lead than the adult CNS. Even low-level lead exposure to the developing brain causes deficits in intelligence quotient, attention, impulse control, and other neurocognitive functions that are largely irreversible.⁷

Children with an elevated BLL may also develop constipation, anorexia, pallor, and pica.⁸ The development of geophagia (subtype of pica in which one craves and ingests nonfood clay or soil-like materials), represents a "chicken-or-egg" phenomena as it both causes and results from lead poisoning.

Lead impairs multiple steps of the heme synthesis pathway, causing microcytic anemia with basophilic stippling.

Lead-induced anemia exacerbates pica as anemic patients are more likely to eat leaded paint chips and other lead-containing materials such as pottery.⁸ Of note, leaded white paint is reported to have a pleasant taste due to the sweet-tasting lead acetate used as a pigment.

The most dramatic and consequential manifestation of lead poisoning is lead encephalopathy. This can occur at any age, but manifests in children at much lower BLLs than in adults. Patients can be altered or obtunded, have convulsive activity, and may develop cerebral edema. Encephalopathy is a life-threatening emergency and must be recognized and treated immediately. Lead encephalopathy should be suspected in any young child with hand-to-mouth behavior who has any of the above environmental risk factors.⁴ The findings of anemia or the other diagnostic signs described below are too unreliable and take too long to be truly helpful in making the diagnosis.

How is the diagnosis of lead poisoning made?

The gold standard for the diagnosis of lead poisoning is the measurement of BLL. However, the turnaround time for this test is usually at least 24 hours, but may take up to several days. As such, adjunctive testing can accelerate obtaining a diagnosis. A complete blood count (CBC) to evaluate for microcytic anemia may demonstrate a characteristic pattern of basophilic stippling.⁹ A protoporphyrin level—either a free erythrocyte protoporphyrin (FEP) or a zinc protoporphyrin level—will be elevated, a result of heme synthesis disruption.⁹ Urinalysis may demonstrate glycosuria or proteinuria.⁶ Hypertension is often present, even in pediatric patients.

An abdominal radiograph is essential in children to determine whether a lead foreign body, such as a paint chip, is present in the intestinal lumen. Long bone films may demonstrate "lead lines" at the metaphysis, which in fact do not reflect lead itself but abnormal calcium deposition in growing

Table 2. Chelation Therapy for Elevated Blood Lead Levels⁵

Agent	Indications	Dosing	Notes
Succimer	Blood lead level 45-69 mcg/dL (children), 70-100 mcg/dL (adults)	700-1,050 mg/m ² /d	Unpalatable; must be mixed with nondairy food
Calcium disodium edetate (EDTA)	Blood lead level >69 mcg/dL (children), >100 mcg/dL (adults) Any patient with encephalopathy	1,000-1,500 mg/m ² /d	Continuous infusion or divided doses Potentially nephrotoxic
British anti-Lewisite (BAL)	Blood lead level >69 mcg/dL (children), >100 mcg/dL (adults) Any patient with encephalopathy	300-450 mg/m ² /d	Painful; suspended in peanut oil; must be given via intramuscular injection. Contraindicated in patients with peanut allergy.

bone due to lead's interference with bone remodeling. A computed tomography (CT) scan of the brain in patients with encephalopathy will often demonstrate cerebral edema.⁶

Of note, capillary BLLs taken via fingerstick can be falsely elevated due to contamination during collection (eg, the presence of lead dust on the skin). However, this screening method is often used by clinicians in the pediatric primary care setting because of its feasibility. Elevated BLLs from capillary testing should always be followed by a BLL obtained by venipuncture.²

Case Continuation

The patient's mother was counseled on sources of lead contamination. She was informed that although drinking water may contribute some amount to an elevated BLL, the most likely source of contamination is still lead paint found in older homes such as the one in which she and her son resided.

Diagnostic studies to support the diagnosis of lead poisoning were performed. A CBC revealed a hemoglobin of 9.8 g/dL with a mean corpuscular volume of 68 fL. A microscopic smear of blood demonstrated basophilic stippling of red blood cells. An FEP level was 386 mcg/dL. An abdominal radiograph demonstrated small radiopacities throughout the large intestine, without obstruction, which was suggestive of ingested lead paint chips.

What is the best management approach to patients with suspected lead poisoning?

The first-line treatment for patients with lead poisoning is removal from the exposure source, which first and foremost requires identification of the hazard through careful history taking and scene investigation by the local health department. This will avoid recurrent visits following successful chelation for repeat exposure to an unidentified source. Relocation to another dwelling will often be required for patients with presumed exposure until the hazard can be identified and abated.

Patients who have ingested or have embedded leaded foreign bodies will require removal via whole bowel irrigation or surgical means.

Following decontamination, chelation is required for children with a BLL more than 45 mcg/dL, and adults with CNS symptomatology and a BLL more than 70 mcg/dL. **Table 2** provides guidelines for chelation therapy based on BLL.⁵

There are three chelating agents commonly used to reduce the body lead burden (**Table 2**).⁵ The most common, owing largely to it being the only agent used orally, is succimer (or dimercaptosuccinic acid, DMSA). The second agent is calcium disodium edetate (CaNa₂EDTA), which is given intravenously. In patients with encephalopathy, EDTA should be given after the first dose of the third agent, British anti-Lewisite (BAL; 2,3-dimercaptopropanol), in order to prevent redistribution of lead from the periph-

eral compartment into the CNS.¹⁰ However, BAL is the most difficult of the three agents to administer as it is suspended in peanut oil and is given via intramuscular injection every 4 hours.

Unfortunately, while chelation therapy is highly beneficial for patients with severe lead poisoning, it has not been demonstrated to positively impact children who already have developed neurocognitive sequelae associated with lower level lead exposure.¹¹ This highlights the importance of prevention.

Work-up and Management in the ED

The patient with lead poisoning, while an unusual presentation in the ED, requires specialized management to minimize sequelae of exposure. Careful attention to history is vital. When in doubt, the EP should consult with her or his regional poison control center (800-222-1222) or with a medical toxicologist or other expert.

There are several scenarios in which a patient may present to the ED with lead toxicity. The following scenarios, along with their respective clinical approach strategies, represent three of the most common presentations.

Scenario 1: The Pediatric Patient With Elevated Venous Blood Lead Levels

The EP should employ the following clinical approach when evaluating and managing the pediatric patient with normal mental status whose routine screening reveals a BLL sufficiently elevated to warrant evaluation or admission—perhaps to discontinue exposure or initiate chelation therapy.

- Obtain a history, including possible lead sources; perform a complete physical examination; and obtain a repeat BLL, CBC with microscopic examination, and renal function test.
- Obtain an abdominal film to look for radiopacities, including paint chips or larger ingested foreign bodies.
- If radiopaque foreign bodies are present on abdominal radiograph, whole bowel

irrigation with polyethylene glycol solution given via a nasogastric tube at 250 to 500 cc/h for a pediatric patient (1 to 2 L/h for adult patients) should be given until no residual foreign bodies remain.

- Obtain a radiograph of the long bone, which may demonstrate metaphyseal enhancement in the pediatric patient, suggesting long-term exposure.
- Ensure local or state health departments are contacted to arrange for environmental inspection of the home. This is essential prior to discharge to the home environment.
- Begin chelation therapy according to the BLL (Table 2).

Scenario 2: Adult Patients Presenting With Signs and Symptoms of Lead Toxicity

The adult patient who presents to the ED with complaints suggestive of lead poisoning and whose history is indicative of lead exposure should be evaluated and managed as follows:

- Obtain a thorough history, including the occupation and hobbies of the patient and all family members.
- Obtain vital signs to evaluate for hypertension; repeat BLL, CBC with smear, and serum creatinine test. Perform a physical examination to evaluate for lead lines.
- Obtain radiographic images, which may demonstrate a leaded foreign body, such as in the patient with prior history of gunshot wounds.
- If the BLL is sufficiently elevated or clinical findings are sufficiently severe, admit for chelation.

Scenario 3: The Pediatric or Adult Patient Presenting With Altered Mental Status

The patient presenting with altered mental status of unclear etiology—regardless of age—and in whom lead encephalopathy is a possible cause, should be worked-up and managed as follows:

- Obtain BLL, CBC, FEP levels. Consider radiographic imaging to assess for

ingested or embedded foreign bodies.

- If abnormalities in the above laboratory studies are consistent with lead poisoning, initiate chelation immediately—prior to receiving repeat BLL result.
- Obtain a CT scan of the head to assess for cerebral edema.
- Provide supportive care for encephalopathy, including airway control and management of increased intracranial pressure.

Case Conclusion

The patient was admitted to the hospital for whole bowel irrigation and chelation

therapy with succimer. The local health department conducted an investigation of the home and found multiple areas of peeling lead paint and lead dust, and ordered remediation of the property before it could be re-occupied by the family. A test of the home's drinking water found no elevation above the 15 ppb standard.

The patient was discharged from the hospital in the care of his mother. They were relocated to a lead-free home, with follow-up by the pediatrician for ongoing monitoring of the BLL and developmental milestones.

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