Lead

Keith Cross, MD, MSc

What is food to one, is to others bitter poison.

—Lucretius

Learning Objectives:
1. Identify sources of environmental lead exposure
2. Describe acute and chronic problems caused by lead poisoning
3. Become familiar with screening recommendations and available tests
4. Review treatment of children with elevated lead levels

Primary Reference:
http://pediatrics.aappublications.org/content/pediatrics/early/2016/06/16/peds.2016-1493.full.pdf

CASE ONE:

Mr. and Mrs. Plumbum bring their active 15-month-old daughter to see you for a routine well child check. They say she is healthy and developing well. She walks well and “gets into everything.” She can stack two blocks and speaks more than 10 words. Along with your usual anticipatory guidance and immunizations, you review the lead screening done at the girl’s 12-month check up. The blood lead level (BLL) is elevated at 17 mcg/dL; it was done via a capillary (finger-stick) test.

1. What are the main sources of lead in the environment that contribute to elevated lead levels in children like this one?

By far the most common exposure is lead in paint. Since 1978, when the United States fully banned lead paint, about 75% of homes have been rendered “lead safe” - implying that 25% or so still have some degree of lead paint. Young, inquisitive children may play with paint chips and put them in their mouths. Additionally, paint chips deteriorate into dust, which contaminates indoor floors, windowsills, and other surfaces. This dust gets on children’s hands and eventually into their mouths.

Ordinary outdoor soil may also have elevated lead levels (due to decades of burning leaded gasoline) and children may ingest the lead-enriched soil while playing. Old homes with lead pipes can introduce lead via drinking water, which is primarily an issue for infants who drink formula reconstituted with tap water. Other potential sources include smelters or industrial manufacturing sites, glazes on imported ceramics, imported toys, certain spices and folk remedies (particularly from Asian and Latin American countries), and coatings on mini-blinds made before 1998, which can all bring lead into contact with children. In immigrants and international adoptees, the risk of lead exposures can be much higher in their countries of origin, which may have fewer lead abatement standards and may still use leaded gasoline. Finally, parents with occupational exposures can bring lead home on their clothes and hands.

2. What can the family do to identify and remove sources of lead and reduce the child’s exposure?

Qualified inspectors can carry out formal inspections of the family’s home. Many states have programs through the Department of Public Health to help families to get their homes inspected. A professional inspection followed by abatement (if needed) is most important. Recommended abatement methods may include enclosure with paneling, paint removal, replacement of doors and windows, and
encapsulation by new paint. More information on lead abatement is available to providers and patients online (see Resources section).

Beyond inspection and abatement, some simple measures are recommended, but they are not necessarily evidence-based. Hand washing before meals or after playing outside is likely to be useful. Eliminating lead containing hobbies or items, adding doormats, and keeping all shoes at the entry (i.e., no shoes in the house) should decrease the amount of lead-containing dust in the home. Running cold water for a minute or two may flush pipes of water that has been standing in them and had time to dissolve lead, assuming the home’s plumbing still has lead components. Frequently used toys can be matched against lists of recalled products (see Resources); many providers post recall announcements in their offices. Parents whose occupations involve lead should change clothes and wash their hands before coming home.

While implementation of these measures would seem to make sense, the US Preventive Services Task Force (USPSTF) recently “found no studies evaluating neurocognitive outcomes after residential lead hazard-control efforts or nutritional interventions. These interventions were found to have small, inconsistent, or unsustained effects on BLLs in asymptomatic children with mildly-to-moderately increased BLLs (<45 mcg/dL).” As a result, the USPSTF concluded “that evidence is insufficient to recommend for or against routine screening for elevated BLLs in asymptomatic children aged 1 to 5 who are at increased risk.” Likewise, a recent Cochrane Database meta-analysis also failed to find good evidence that any specific household interventions affect outcomes.

On the other hand, multifaceted programs to reduce lead exposure seem to be paying off overall, even if specific interventions lack supporting evidence. Studies of US National Health and Nutritional Examination survey data reveal that mean blood levels and the percentages of children with levels ≥5 mcg/dL have steadily fallen since 1999, from 1.65 mcg/dL and 9.9% in 1999-2000, to 0.84 mcg/dL and 0.5% in 2013-2014. These data are averages that include populations with minimal exposure to lead. Among certain risk groups, rates are much higher. For example, 15% of US children living in pre-1950 housing have lead levels ≥5 mcg/dL. Poverty, old housing, and non-Hispanic black race remain the biggest risk factors for elevated lead levels in children.

Consequently, the AAP, CDC, American Academy of Family Physicians, and American College of Preventive Medicine all recommend more liberal screening practices - in contrast to the USPSTF. Medicaid mandates screening for elevated BLL at 12 and 24 months as part of the Early and Periodic Screening, Diagnostic, and Treatment Program (EPSDT), a strategy endorsed by the AAP and CDC since this approach, targeted to the highest-risk children (i.e., Medicaid-eligible), will detect most affected children. Additionally, the AAP recommends screening at 12 and 24 months for all children who live in communities with ≥25% of housing built before 1960, or a ≥5% community prevalence of childhood lead levels ≥5 mcg/dL. Providers must have a firm understanding of local risk factors and guidelines in order to properly implement these guidelines.

3. What are your concerns about the possible effects of the elevated lead level in this child?

Most lead exposure does not cause noticeable illness, although the level at which lead causes acute problems such as gastrointestinal upset, anemia, and encephalopathy may vary from one child to the next. Acute clinical symptoms are rare below lead levels of 60 mcg/dL.

A bigger concern is the chronic impact of lead on IQ, scholastic performance, and behavior, usually not measurable until age 5 (although lead levels typically peak around age 2). Canfield and colleagues found an estimated IQ loss of 4.6 points for each 10 mcg/dL increase in BLL. A careful follow-up at age 7-8 years of 488 children with lead levels recorded at 30 months of age by Chandramouli, et al. showed little effect of lead levels below 5 mcg/dL, but above 5 mcg/dL there was significant reduction in reading, writing, and spelling performance on standardized tests, and increases in antisocial behavior and hyperactivity. The effect was larger among children with early lead levels >10 mcg/dL. Another large, pooled analysis of the intellectual effects of low level lead by Lanphear, et al. suggested that even at small doses lead can reduce cognitive function. McLaine, et al. showed level lead as low as 5 mcg/dL was associated with worse pre-reading skills at the start of kindergarten. Accordingly, the CDC and AAP set a cut-off for abnormal screening results at 5 mcg/dL for children under age 6.
These long-term neurologic and behavioral effects occur even if the child’s lead level is corrected. In other words, damage appears to happen early in kids, and may not be reversible. For these reasons, prevention is paramount. Once lead levels are elevated, damage may already be done, and we treat such children hoping to prevent any further damage.

4. **What interventions (public health, testing, and treatment) are needed for the child?**

Most states require a report to be made by the laboratory finding an elevated blood level to the state and local departments of health. The AAP recommends that health care providers inform state or local health departments for any child with an elevated lead level to assist with housing inspection and risk reduction.

The USPSTF has found that capillary blood lead sampling has false-positive rates of 3% to 9%, and false-negative rates of 1% to 8%. Since this is partially due to contaminated skin, the hand should be carefully washed prior to collection, the skin puncture should be adequate to maintain good blood flow, and the collection devices may be pre-checked for contamination. Elevated capillary blood lead levels should be confirmed with venous blood draw testing for lead, which is more accurate. Traditionally, a hemoglobin/hematocrit, iron panel, and zinc protoporphyrin (ZPP) level are sent at the same time. ZPP is elevated when iron levels are low, as in the case of chronic lead exposure. It is formed when zinc, instead of iron, is incorporated into protoporphyrin during heme biosynthesis. It is a poor screening test but is useful when tracking the effect of chelation treatment.

Testing for lead in hair has not been found to be useful. Radiographic measurements of lead in bone, while used in some research applications, has no clinical application at this time.

Chelation is not indicated for this patient, but environmental and dietary education, with specific focus on calcium, iron, and vitamin C, is warranted. Adequate iron and calcium stores appear to reduce lead absorption, and vitamin C enhances lead excretion. The key intervention remains identifying and removing environmental sources of lead exposure.

For children with capillary lead levels between 15 and 44 mcg/dL, like this one, the AAP recommends confirmatory venous testing in 1 week to 1 month. If the level is indeed elevated (i.e., ≥5 mcg/dL), then two or more serial venous measurements at 1-3 month intervals should be performed to document stability or decline. Once declining, levels can be followed every 3-6 months until <5 mcg/dL. The urgency of confirmatory testing and frequency of serial measurements should be guided by the degree of elevation. Refer learners to table 5 in the AAP Policy Statement (noted in the primary references above) for detailed management recommendations.

**CASE TWO:**

Mrs. Plumbum subsequently brings in her other child, a 3-year-old boy. He has not received preventive healthcare in “quite a while” but reportedly is very healthy. However, because of his sibling’s lead level, his mom is now appropriately concerned about his exposure to lead. A capillary test for lead is sent and comes back at 52 mcg/dL. You call Mrs. Plumbum to discuss the results.

5. **What public health, testing, and/or treatment interventions are needed for this child? What is the timeline for these interventions?**

This elevated level should be reported to the state and local community health departments. The blood level should be repeated with a venous sample within 48 hours and if again >44 mcg/dL the child will need oral chelation treatment. Succimer (10 mg/kg/dose) is usually given orally every 8 hours for 5 days, then every 12 hours for an additional 14 days. It has a “rotten eggs” smell and children are often reluctant to take it. For more serious lead poisoning (≥70 mcg/dL), children are typically admitted to the hospital for chelation treatment, often at a referral center (see below). Chelation is typically performed with calcium disodium EDTA, although British Anti-Lewisite (BAL) is an older alternative.

Additional testing should include hemoglobin, iron and ferritin levels, and a ZPP. If a history suggests the child has ingested paint chips or other lead-containing material, an abdominal film should be
obtained to see if there are radiodense objects amenable to bowel cleansing. Often children are temporarily removed from their primary residence (sometimes admitted to the hospital) until the home can be inspected. As mentioned above, education is a crucial part of the intervention.

6. To whom do you refer this child and how do you reach them?
Most states offer a service either via the local health department or via prominent hospitals that will assist primary care providers in their management. Many communities that have high rates of lead exposure have established local lead programs. Information about state-specific programs and contacts can be found online (see Resources).

Additional References:

Resources:
3. CDC Lead Poisoning Prevention Program with information for patients and providers. http://www.cdc.gov/nceh/lead/acclpp/blood_lead_levels.htm