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ABSTRACT

These Illinois guidelines provide information on the medical management and treatment of children with lead poisoning, based on Federal guidelines (revised in 1991) for determining lead poisoning at lower levels. The guidelines outline the effects of lead poisoning, sources of lead, estimated incidence of lead poisoning in Illinois, screening guidelines, risk factors, diagnostic guidelines, medical management, treatment and follow up, and the role of the Illinois Department of Public Health, and community intervention. Appendixes provide procedures for specimen collection, a questionnaire to determine risk, a protocol for identifying children with significant lead burdens, advice to parents for preventing lead poisoning, and a 33-item bibliography. (JDD)

# Illinois Department of Public Health

# Guidelines for the Detection and Management of Lead Poisoning for Physicians and Health Care Providers

April 1992

*A Healthier Today For A Better Tomorrow*

# GUIDELINES FOR THE DETECTION AND MANAGEMENT OF LEAD POISONING FOR PHYSICIANS AND HEALTH CARE PROVIDERS

Illinois Department of Public Health
Office of Community Health
Division of Family Health
Childhood Lead Poisoning Prevention Program

April 1992

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## PREFACE

Guidelines For The Detection and Management of Lead Poisoning was developed by the Illinois Department of Public Health, with the assistance of the Medical Advisory Committee for the Childhood Lead Poisoning Prevention Program, the Illinois State Medical Society, the Illinois Chapter of the American Academy of Pediatrics, and the Illinois Academy of Family Physicians. The Guidelines are being distributed to physicians and health care providers statewide to provide information on the new federal guidelines for determining lead poisoning at lower levels and to provide updated information on the medical management and treatment of children with lead poisoning.

The physicians participating in the development of this document have vast experience in screening and treating children with lead poisoning. Their input was vital and should help other physicians and health care providers who treat young children with lead poisoning.

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## INTRODUCTION

Childhood lead poisoning is one of the most common and preventable pediatric health problems in the United States today. Children are particularly susceptible to lead's toxic effects. The Agency for Toxic Substances and Disease Registry estimated that in 1984, 17 percent of all American preschool children had blood lead levels exceeding 15 mcg/dl. **Because of evidence showing adverse effects at low blood lead levels, new guidelines from the Centers for Disease Control have changed the definition of lead poisoning to a blood lead level greater than or equal to 10 mcg/dl.**

Lead poisoning is a public health problem of continuing importance. Our understanding of it has also evolved over the past two decades. In the early 1970s, physicians struggled to save critically ill children with this problem. Some died of lead poisoning, and the survivors were left with severe mental retardation. The medical community responded by developing improved diagnostic tests and treatment. Public health advocates pushed for crucial legislation that decreased the amount of lead in gasoline, new paint, metal solder, and pipes in plumbing. As a result, few children suffer from the effects of lead encephalopathy but, unfortunately, since a great deal of old leaded paint exists in older housing, thousands are exposed to lower doses of lead which result in subtle but serious problems.

Currently in Illinois, approximately 105,000 screenings are provided annually through the efforts of local health departments, private physicians and other health service providers. Approximately 2,000 cases of lead poisoning in children were identified in FY91 (1990-1991). There are approximately one million children younger than age 6 living in Illinois. Therefore, only a small percentage of these children are screened and identified with lead poisoning. The Second National Health and Nutrition Survey (HANES II), 1983, estimated that 3 percent of the preschool population is affected by lead toxicity, with blood lead levels in excess of 25 mcg/dl. Using 1980 census data, it is estimated that 28,000 preschool children in Illinois have significant lead poisoning, with blood levels greater than 25 mcg/dl. Therefore, approximately 25,974 cases of lead poisoning, or 96 percent of children with blood lead levels greater than 25 mcg/dl and with lead poisoning serious enough to have lasting effects, are unidentified. **It is estimated that approximately 175,000 young children (17%) in Illinois are at risk of low level (≥15 mcg/dl) lead poisoning.**

To combat this pediatric health problem, community intervention programs need to be established. A comprehensive community intervention program to address childhood lead poisoning must include outreach and education for families and health care providers; screening of children younger than age 6; referral of children who require medical follow-up for timely diagnostic evaluations; and identification of lead sources and prompt abatement.

In view of new scientific data, we must respond with a renewed and vigorous effort to eliminate sources of lead from the environment. We must search for all children with early lead poisoning to prevent further damage. Our goal must be prevention of this **"Silent Epidemic."**

Children with blood lead levels greater than 10 mcg/dl are at risk for adverse effects. Actions must be taken to protect their health. A series of community-level interventions can be taken by cities and towns which suspect that a substantial percentage of their preschool children may have blood lead levels of 10 mcg/dl or above. These interventions include surveillance to determine the scope of the problem, public awareness campaigns and prevention education.

## OVERVIEW OF THE EFFECTS OF LEAD

**There is no biologic function or need for lead. There is no such thing as a "normal" lead level, only that level which we are willing to tolerate.**

Lead is a toxic substance that injures children starting even before birth. It damages the central nervous system, the peripheral nervous system, the hematopoietic system, regulation of vitamin D, and the kidneys. Very high levels of lead can cause seizures, coma and death. If the child survives, he/she may have severe mental retardation. With lower levels, a child may suffer from developmental delay, a lower IQ, hyperactivity, learning disabilities, behavioral problems, impaired hearing, and stunted growth. Much of the damage to the brain is irreversible.

Lead is most dangerous to the young child and the developing fetus. Young children are more likely to ingest or inhale lead because of their proximity to the floor and frequent hand to mouth behaviors. Given a certain quantity of lead ingested, a child will absorb a larger fraction than will an adult. Concomitant iron deficiency enhances lead absorption from the GI tract. Children have more trouble than adults sequestering lead in their bones, so a larger fraction of the body burden of lead is available to targeted organs. Developing brains are also more susceptible to the toxic effects of lead. Children develop rapidly in their early years, a time when lead poisoning has its most devastating effects. Fetuses are impacted with lead passed through the placenta from a woman with lead in her system. The effects of lead poisoning on the brain and central nervous system are irreversible and cause delays in emerging cognitive and language development.

New research findings suggest blood lead levels as low as 10 mcg/dl, which do not cause distinctive symptoms, are associated with decreased intelligence and slowed neurobehavioral development. Many other effects begin at these low blood lead levels. Fetal lead exposure has been shown to decrease stature and affects the ability to maintain steady posture. The affects of lead on decreased hearing acuity have no apparent threshold.

Lead's impairment of the biosynthesis of the active vitamin D metabolite is detectable at blood lead levels of 10 mcg/dl to 15 mcg/dl. It has been shown that lead poisoned children have lower serum total and ionized calcium levels. Maternal cord blood lead levels of 10 to 15 mcg/dl appear to be associated with reduced gestational age and reduced weight at birth.

## SOURCES OF LEAD

**Lead-based paint and lead-contaminated dusts remain the primary sources of lead exposure for children.** Nationwide, lead remains in approximately 74 percent of all private housing units built before 1978. Housing built before 1950 is at even greater risk of having interior lead-based paint. Household dust may also contain significant amounts of lead. This lead is in a much more absorbable form. Children can swallow it by chewing or sucking dusty toys and fingers. Lead burdened dust may also be inhaled. Lead in dust is increased after older paint has been disturbed. **Children and pregnant women should never be allowed to remain in a house that is undergoing renovation.**

Other sources of lead are less prevalent. However, several low level sources together can accumulate significantly. Lead can be found in water and soil.

Lead in water is a less frequent but significant source. Water pipes and especially the solder that connects them may contain lead. If lead in plumbing is suspected, water from a hot water tap should not be used for drinking or food preparation. The cold water tap should be flushed for several minutes each morning or until there is a noticeable change in temperature of the water before any water is consumed.

Lead in soil is also a lesser cause of poisoning. Lead has been deposited in soil from leaded gasoline, lead paint dust and industries using lead. Food grown in city gardens may be contaminated with lead from the soil. Children's outside play areas may be contaminated with lead from air pollution and paint from the outside of buildings. Outside play areas should be located away from houses and buildings and away from areas that could have been contaminated by heavy traffic.

Lead in food has been dramatically reduced due to voluntary reduction of its use by food manufacturers. Lead solder is much less commonly used for canned foods. However, it is important to transfer the food from opened cans into glass or plastic containers immediately. Metal cans with dented seams should be discarded without opening. Recent information notes that bread wrappers are printed with lead based paint. Bread wrappers/bags should not be turned inside out and reused. Other sources of lead include gasoline sniffing, poorly glazed ceramic dishes, and folk medicines.

## SCREENING

The primary goal of a lead poisoning screening is to identify symptomatic or asymptomatic lead-poisoned children and to intervene as quickly as possible to reduce their blood lead levels. **Most cases identified will be asymptomatic.**

**Symptomatic lead poisoning is a medical emergency.**

Screening may also be used to collect and evaluate data to target community-wide interventions in areas with children at high risk for lead poisoning. In Illinois, Public Act 87-175 requires every physician or health care provider to screen children 6 months to 6 years of age for lead poisoning, in accordance with guidelines and criteria set forth by the American Academy of Pediatrics at the priority intervals and using the methods specified in the guidelines, children 6 years and older may also be screened by physicians or health care providers in accordance with guidelines and criteria set forth by the American Academy of Pediatrics.

The new CDC guidelines (October 7, 1991) change the definition of lead poisoning to a blood lead level greater than or equal to 10 mcg/dl. Because the Erythrocyte Protoporphyrin level is not adequately sensitive to identify children with elevated blood lead levels below about 25 mcg/dl, **the screening test of choice is a blood lead measurement. Capillary specimens will be more feasible for screening purposes.** Capillary specimens can be contaminated by lead containing dust from the child's hand. Contamination of capillary specimens can be minimized if proper collection technique is followed. See Appendix A for information on specimen collection. Before a child undergoes further diagnostic assessment, a confirmatory venous blood lead measurement should be taken, even if the child was initially screened using a venous blood sample. **Diagnostic blood lead levels must be measured on venous samples.**

**Because all children are at risk for lead poisoning, it is recommended that all children be screened. Those children at highest risk for lead poisoning however, are the highest priority for screening. CDC recommends universal screening be phased in except in communities where large numbers of children have been identified with lead poisoning. Health care providers should initially focus their efforts on screening high risk children and phase in universal screening over time.**

## ANTICIPATORY GUIDANCE AND RISK ASSESSMENT

**Anticipatory guidance helps prevent lead poisoning by educating families on ways to reduce lead exposure.**

**Questions about housing and other factors are used to identify which children are at greatest risk for high-dose lead exposure.**

**Anticipatory guidance and risk assessment should be tailored to important sources and pathways of lead exposure in the child's community.**

Assessment of the risk of lead poisoning should be part of routine pediatric well child care. Starting at 6 months of age and at each regular office visit thereafter, each child should receive a brief assessment, to determine whether the child is at risk for lead. The issue of lead poisoning and recommended actions to reduce the risk of environmental exposure should become a consistent component of anticipatory guidance routinely provided at well child visits. A sample questionnaire appears in Appendix B.

Based on the assessment, children can be categorized as low or high risk for lead poisoning. If the answers to all questions are consistently negative, the child is at low risk for lead poisoning and should be screened with a blood lead test at 12 months, and, if possible, at 24 months. If the answer to any question is positive, the child is potentially at high risk for lead poisoning, and a blood lead test should be obtained. For children previously at low risk, any history suggesting that exposure to lead has increased should be followed up with a blood lead test.

Some children are at higher risk than the general population. For them, routine screening may not be sufficient. There may even be some children who will need screening as often as every two to three months, especially in the summer. A list of potential situations follows.

## Situations that Place Children at High Risk for Lead Poisoning

1. Children with signs and/or symptoms compatible with lead poisoning; such as loss of appetite, abdominal cramps, constipation, anemia, apathy, lethargy or periodic vomiting.

2. Children who have previously had an elevated lead level, even if it has returned to an acceptable level in the interim.

3. Children living in a building where a lead hazard has been found, even in another apartment.

4. Children who live in, or are frequent visitors to, housing constructed before 1978 that is poorly maintained.

5. Children who live in older housing that is being or has been renovated while the children are or were living or visiting there.

6. Children who are siblings, housemates, visitors, and playmates of children with known lead toxicity.

7. Children whose parents or other household members participate in a lead-related occupation or hobby. This includes painters and those who engage in jewelry making, pottery glazing, stained glass work, antique ceramic doll painting, and soldering of metal sculptures.

8. Children who live near heavy traffic areas, near hazardous waste sites or solid waste incinerators where lead is a major pollutant or near a lead smelter or processing plant.

9. Children with pica or frequent hand-to-mouth activity, such as thumb-sucking. These children might also have had an incidence of an accidental ingestion of another hazardous substance.

10. Children with failure to thrive.

11. Children with a history of an accidental ingestion of any nonedible item.

The following is a list of occupations that have been found in Illinois and elsewhere, to carry a potential for exposure to lead. Such exposure represents a risk not only to the worker, but to members of the worker's family as well, unless good hygiene is observed to avoid bringing lead dust into the home from the work place. It is important to note that this list is not complete. Most persons working in an industry using lead are aware of their lead exposure.

Lead Smelting
Battery Manufacture and Reclamation
Radiator Repair
Pottery Manufacture
Automotive Machine Shop Work
Electronics (soldering)
Spray Painting (if using lead-based paint)
House or Barn Paint Removal
Firing Range Supervision
Firing Range Workers
Gasoline Refining
Glass Manufacturing using purchased glass
Casting Bullets (hobby)
Stained Glass Window Design (hobby)
Printing (if involving the manufacture, use or reclamation of lead printing surfaces)
Cable Stripping
Cable Splicing
Die Casting
Valve and Pipe Fittings (except brass goods)
Plumbing Fixture Fittings and trim (except brass goods)
Bridge, tunnel and elevated highway construction

## Screening Schedule

Ideally, all preschool children should be screened for lead poisoning. Those children at highest risk for lead poisoning, however, are the highest priority for screening. The following is the suggested screening schedule for children. In general, children who have capillary blood levels ≥15 mcg/dl should have venous confirmation of these levels.

1. All children between the ages of six and 72 months should receive, as part of routine Well-Child Care, a risk assessment to determine potential environmental exposure to lead. It is recommended that providers utilize a structured risk assessment process such as the sample questionnaire in Appendix B.

2. Children identified by risk assessment as low risk for lead poisoning should be screened at 12 months of age and again at 24 months, if indicated. The priority placed on screening low risk children should be based on the physician's judgment regarding the probability of lead exposure and the risk status of the community.

   - If the blood lead level is <10 mcg/dl, the child's risk for lead exposure should be monitored at subsequent Well-Child visits.
   - If the blood lead level is 10-14 mcg/dl, the child is in Class IIA and should be rescreened in six months. If the level has not increased over that time, the child's risk for lead exposure should be monitored at subsequent Well Child visits.
   - If the blood lead level is 15-19 mcg/dl, the child is in Class IIB and should be rescreened every three months until level is below 15 mcg/dl.

3. Children at high risk for lead poisoning by risk assessment must receive a blood lead screening.

   - If the blood lead level is <10 mcg/dl, the child should be rescreened annually at subsequent Well-Child visits.
   - If the blood lead level is 10-14 mcg/dl, the child is in Class IIA and should be rescreened every six months.
   - If the blood lead level is 15-19 mcg/dl, the child is in Class IIB and should be rescreened every three months until level is below 15 mcg/dl.

4. **Children should be screened any time risk assessment or history suggests that exposure to lead may have increased (i.e., child living in an old house undergoing renovation).**

5. **Children six years to 16 years of age with a history suggestive of past or present lead exposure, learning disabilities or other learning problems, should be screened for lead poisoning.**

## LABORATORY ANALYSIS FOR LEAD SCREENING

The Illinois Department of Public Health recommends that specimens requiring laboratory analysis for lead screening be submitted to its Division of Laboratories, the Chicago Department of Health Laboratory or a private laboratory. The State laboratory will provide supplies including Lancets, Microvettes, Vacutainer tubes, request forms, and mailing containers to submitters. Test results are mailed from the laboratory. Test results greater than 45 mcg/dl are called to the submitter and local health department by the Childhood Lead Poisoning Prevention Program. In case of a medical emergency, you may call the State Laboratory at 217/782-6562.

Physicians in private practice and small clinics are encouraged to participate in the Physicians' Mail-In Program for Lead Detection. To enroll, please call the Childhood Lead Prevention Program at 217/785-5246 for a provider number and further information. In Chicago, call the City of Chicago Department of Public Health's Childhood Lead Poisoning Program at 312/747-0100.

## CASE DEFINITION

The Guidelines from the Centers for Disease Control provide case definitions and recommendations for follow-up as indicated in Table 1 and Table 2.

Table 1 presents the timetables for confirming screening results and determining case definition based on the new CDC Guidelines.

**TABLE 1. Case Classification for confirming blood lead results**

| Blood lead level (mcg/dl) | Presumptive Class | Time within which venous blood lead should be obtained |
|---|---|---|
| ≤9 | I | Not applicable |
| 10-14 | IIA | Not applicable |
| 15-19 | IIB | Within 1 month |
| 20-44 | III | Within 1 week |
| 45-69 | IV | Within 48 hours |
| ≥70 | V | Immediately |

Table 2 presents interpretation of blood lead test results and follow-up activities.

**TABLE 2. Interpretation of blood lead test results and follow-up activities: class of child based on blood lead concentrations.**

| Class | Blood lead concentration (mcg/dl) | Comment |
|---|---|---|
| I | ≤9 | A child in Class I is not considered lead poisoned. |
| IIA | 10-14 | Many children (or a large proportion of children) with blood lead levels in this range should trigger community-wide childhood lead poisoning prevention activities. Children in this range may need to be rescreened more frequently. |
| IIB | 15-19 | A child in Class IIB should receive nutritional and educational interventions and more frequent screening. If the blood lead level persists in this range, environmental investigation and intervention should be done. |
| III | 20-44 | A child in Class III should receive medical evaluation. Such a child may need pharmacologic treatment of lead poisoning. Environmental evaluation and remediation should take place. |
| IV | 45-69 | A child in Class IV needs both medical and environmental interventions, including chelation therapy. |
| V | ≥70 | A child with Class V lead poisoning is a medical emergency. Medical and environmental management must begin immediately. |

Note: The margin for error for laboratory measurement is + or - 5 mcg/dl. on these levels below 15 mcg/dl.

## DIAGNOSTIC EVALUATION

**Children with a confirmatory blood lead level of ≥20 mcg/dl, defined as Class III or greater, should receive medical evaluation and follow-up. The urgency of further medical evaluation depends on the blood lead level (BPb) (and the presence of any symptoms).**

**THE SINGLE MOST IMPORTANT FACTOR IN PEDIATRIC CASE MANAGEMENT IS TO DRASTICALLY REDUCE THE CHILD'S EXPOSURE TO LEAD.**

**Screening tests are not diagnostic.** Every child with a positive screening test should be evaluated in a timely manner. In cases of acute poisoning, the rise of the EP may lag behind the lead level and therefore the EP may be normal while the lead is acutely rising.

Children with symptoms that suggest lead poisoning should receive immediate evaluation, regardless of their risk classification. **Symptoms such as loss of appetite, abdominal cramps, constipation, anemia, apathy, lethargy, and periodic vomiting may indicate lead poisoning. Other behavioral disturbances compatible with lead toxicity include clumsiness, hyperirritability, and loss of recently acquired developmental skills.**

**Lead poisoning is a reportable disease.** Physicians, nurses, hospital administrators, laboratories, and health service providers are required to report cases of elevated blood lead levels. **IDPH must be notified of all results greater than 15 mcg/dl. Call 217/782-0403 to receive report forms.** Cases of children living in Chicago should also be reported to the City of Chicago Department of Public Health's Childhood Lead Poisoning Program at 312/747-0100. The Illinois Department of Public Health's Childhood Lead Poisoning Prevention Program will notify the local health department where the child resides.

**The child with an elevated blood lead level (greater than 20 mcg/dl) should have a complete pediatric medical evaluation, giving special attention to the following.**

1. **A detailed history, including the presence or absence of clinical symptoms, child's mouthing activities, existence of pica, nutritional status, dietary habits, family history of lead exposure, speech/language and hearing screenings, assessment of child's developmental status, and previous BPb determinations.**
2. **The physical examination, with particular attention to the neurologic examination.**
3. **Hematologic evaluation for iron deficiency.**
4. **Trends in blood lead levels. (See the paragraph following this chart.)**
5. **Detailed environmental and occupational histories concerning adults in the same household or other caretakers.**

Since trends are important in diagnosis and management, serial measurements of BPb are far more valuable than data obtained at a single point in time. Analytical variability must be considered when interpreting blood lead results. Apparent changes in lead status based on successive blood lead measurements can be considered significant only when the net difference of results exceeds the limit of analytic variance allowed by the

laboratory. As a general rule, trends should not be considered significant unless the magnitude of the change is ≥5 mcg/dl.

The degree of analytical variability between laboratories, which may employ different analytic methods, exceeds that within a single laboratory. Therefore, a single laboratory using one analytical method should be used to best compare multiple blood lead results from an individual or a population. Laboratories have a margin of error up to 5 mcg/dl either way. This variability should be considered when interpreting results.

In addition, an erythrocyte protoporphyrin level should be obtained prior to chelation. EP levels and concurrent measurement of BPb are extremely helpful in following children post-chelation.

TESTS

1. Calcium Disodium EDTA Mobilization (or Provocative Chelation) Test

   The mobilization test is used to determine whether a child (with an initial confirmatory BPb level 25-44 mcg/dl) will respond to chelation therapy. This test provides an index of the mobile or potentially most toxic fraction of total body lead. This test identifies children who will respond to chelation therapy with a brisk lead diuresis and is a better diagnostic predictor than a venous BPb alone. **Children whose BPb is greater than or equal to 45 mcg/dl should not receive a provocative chelation test**, but should be referred for appropriate chelation therapy immediately. (See Appendix C for further details.)

2. Iron Deficiency Test

   Because iron deficiency can exacerbate lead poisoning and often coexists with it, children with BPb greater than or equal to 20 mcg/dl must be evaluated for iron deficiency or this condition. The hemoglobin, hematocrit, and reticulocyte count are not adequately sensitive, and the EP is not specific enough to diagnose iron deficiency. Ferritin is the most sensitive indicator of iron status. Serum iron and iron binding capacity can be used with discretion.

3. Lumbar Puncture **(Caution)**

   The diagnosis of acute lead encephalopathy can usually be made without lumbar puncture, which has considerable risk because of the increase in intracranial pressure.

Flat plate of the abdomen, x-ray of long bones, microscopic examination of red cells for basophilic stippling, and tests of hair and fingernails for lead levels are not sensitive indicators for the diagnosis or clinical management of lead poisoning and are not components of the routine workup of a patient with suspected lead poisoning. However, in certain circumstances, the flat plate of the abdomen may be indicated, such as when there is evidence of lead ingestion.

## MEDICAL MANAGEMENT

### PREGNANT WOMEN

**At present, there is insufficient clinical knowledge or experience with any chelating regimen(s) to recommend treating pregnant women or women of child-bearing age who have elevated BPb levels.** Until further clinical research is carried out, including toxicokinetic, experimental studies of the maternal-fetal unit and sequential measurements of maternal bone lead concentrations during pregnancy, no recommendations can be made. Women of child-bearing age and pregnant women who have blood lead levels above 10 mcg/dl should receive environmental assessments to identify and eradicate sources of excessive lead exposure.

### BREASTFEEDING WOMEN

Women who have blood lead levels greater than 10 mcg/dl should be counseled regarding lead poisoning as lead can be passed to the infant through breastmilk.

### CHILDREN

One of the most important factors in the management of the lead poisoned child is to remove the child from the source of lead or remove the source. Health care providers can play an essential role in identifying the source of lead exposure. Careful environmental and parent's occupational histories must be obtained for all lead-poisoned children. The proximity of family homes to lead industries and high traffic roadways should be determined. Health care providers should advise families never to carry out lead paint removal themselves in their homes or apartments and should warn them of the dangers of renovating or remodelling older homes. Such repairs are safely performed only by trained and licensed contractors. The entire family should be out of the home day and night as the dwelling is properly prepared pre-abatement, during the actual abatement, and until thorough post-abatement clean-up is completed. It is the responsibility of primary care providers to promptly refer children to medical facilities with experience in the prevention, care, and management of lead poisoned children if they are unable to provide this care themselves. See Appendix D for advice to parents.

**General Supportive Management for Symptomatic Lead Poisoning**. For children with a blood lead level >70 mcg/dl and symptoms suggestive of lead encephalopathy, all oral intake is prohibited until the child's condition has significantly improved. Parenteral fluid therapy is started immediately; fluid volume is restricted to basal requirements plus a careful assessment of on-going losses. Excessive intravenous fluid administration should be avoided. Once urine flow is established, chelation treatment, already begun with BAL alone for one dose, is continued with simultaneous administration of $CaNa_2EDTA$. An adequate flow of urine must be established before intravenous chelation therapy with $CaNa_2EDTA$ is begun. Parenteral fluid therapy minimizes vomiting that may accompany administration of BAL and ensures prompt excretion of $CaNa_2EDTA$. For immediate

control of seizures, diazepam or paraldehyde are the preferred drugs. Barbiturate and phenytoin are reserved for the long-term management of recurring seizures, only after the acute encephalopathic episode is managed and consciousness has been fully recovered. Although it is desirable to evaluate any residual lead from the bowel, this must never delay the start of chelation therapy. Management of increased intracranial pressure and cerebral edema should be conducted in a pediatric intensive care setting.

**General Supportive Management for Asymptomatic Lead Poisoning**. For a child whose blood lead is greater than or equal to 45 mcg/dl, general supportive management should follow the guidelines recommended for children with symptomatic lead poisoning.

## MEDICAL TREATMENT

**TREATMENT GUIDELINES FOR CHILDREN WITH BLOOD LEAD LEVELS ≥20 mcg/dl**

- **The most important factor in managing childhood lead poisoning is reducing the child's exposure to lead.**
- **Children with symptomatic lead poisoning, with and without encephalopathy, should be managed by a multidisciplinary team.**
- **Asymptomatic children with blood lead levels ≥45 mcg/dl should receive chelation therapy.**
- **Different clinical centers and programs use different protocols to medically manage children with blood lead levels of 25 to 44 mcg/dl.**

The following medical treatment schedule is recommended for each classification of lead level:

**Blood lead level <10 mcg/dl (Class I).** A blood lead level <10 mcg/dl is not considered indicative of lead poisoning.

**Blood lead level 10 to 14 mcg/dl (Class IIA).** Children with blood lead levels in this range are in a border zone. Since the laboratory tests for measuring blood lead levels are not always accurate and precise at these levels, many of these children's blood lead levels may, in fact, be <10 mcg/dl. Although a detailed environmental history should be taken since an obvious remediable source of lead may be found, it is unlikely there is a single predominant source of lead exposure for most of these children. Thus, a full home inspection is not recommended. It is, however, prudent to try to decrease exposure to lead with some simple interventions. In addition, these children should receive follow-up blood lead testing in about six months. The adverse effects of blood lead levels of 10 to

14 mcg/dl are subtle and are not likely to be recognizable or measurable in the individual child. It is important to make sure that these children' s blood lead levels do not go up.

**Blood lead level 15 to 19 mcg/dl (Class IIB).** Children with venous blood lead levels 15-19 mcg/dl need more careful follow-up. The pediatric health care provider should take a careful history, asking about sources of lead exposure. Parents should receive guidance about interventions to reduce blood lead levels. Children with blood lead levels in this range are at risk for lower than expected IQ and other subtle effects. The effects of lead at these levels are significant enough that the health care provider should emphasize to parents the importance of follow-up screening to make sure the levels have not increased. The provider should also discuss interventions to reduce the blood lead levels. In addition, these children should receive follow-up testing. If their blood lead levels persist at ≥15 mcg/dl, environmental investigation and remediation should be completed, if resources permit. In some communities, childhood lead poisoning prevention programs may be able to manage the environmental investigation and remediation.

**Blood lead level 20 to 24 mcg/dl (Class III).** A child with confirmed Bpb of 20 to 24 mcg/dl will require individual case management by a pediatric health care provider. The child should have a complete pediatric evaluation within 10 working days of the initial confirmation, with special attention to nutritional and iron status. Parents should receive education about lead poisoning that includes information about: 1) the causes and effects of lead poisoning; 2) the need for more routine blood lead testing; 3) possible sources of lead intake and means of reducing intake; 4) nutrition, emphasizing the need for adequate nutrition and foods high in iron and calcium; and 5) resources for further information. Sequential measurements of BPb along with review of the child's clinical status should be done monthly. Children with higher BPb levels require referral for environmental investigation and management. The identification and eradication of specific sources of excessive lead exposure are essential to ensure that BPb levels decrease.

**Blood lead level 25 to 44 mcg/dl (Class III).** Many experienced lead clinics will only make the decision on whether to proceed with chelation therapy for a child with a blood lead level 25 to 44 mcg/dl based on the outcome of a carefully performed $CaNa_2EDTA$ mobilization test (see Appendix C). This approach is recommended in the 1985 CDC Lead Statement, but is not universally done because it is cumbersome, labor-intensive, and difficult to perform. Some clinicians recommend the use of Succimer for treatment of children in this category. Currently FDA limits its recommendations for the use of Succimer to children with BPb levels ≥45. Clinical judgment should be used in this situation.

Supportive management, decreasing the child's exposure to lead from all sources, nutritional interventions (correcting iron deficiency and maintaining adequate calcium intake), and more frequent testing to ensure BPb levels decrease are the minimum medical management for children with these blood lead levels.

**BPb level 45 to 69 mcg/dl (Class IV).** For blood lead values between 45 and 69 mcg/dl, chelation treatment should be limited to $CaNa_2EDTA$ or Succimer. Generally, Succimer would be the preferred chelation agent unless for compliance reasons, $CaNa_2EDTA$ must be used.

$CaNa_2EDTA$ is given for five days at a dose of 1000 $mg/m^2$/day, preferably by continuous infusion or in divided doses intravenously as above. During treatment, evaluate renal and hepatic function and serum electrolyte levels. $CaNa_2EDTA$ treatment should be continued for five days and no longer. A second course of chelation therapy with $CaNa_2EDTA$ alone may be required if the BPb concentration rebounds to ≥45 mcg/dl within 7 to 14 days after treatment. It is prudent to allow a period of five to seven days before beginning a second course of $CaNa_2EDTA$. (Refer to page 20 for Succimer schedule.)

**Blood lead level ≥70 mcg/dl (Class V).** Children with BPb levels ≥70 mcg/dl (with or without symptoms) represent an acute medical emergency. If the BPb level is ≥70 mcg/dl, both BAL and $CaNa_2EDTA$ should be given, in the same doses and using the same guidelines as for treatment of symptomatic lead poisoning (see Table). A second course of chelation therapy with $CaNa_2EDTA$ alone may be required if the BPb concentration rebounds to a level of ≥45 mcg/dl within five to seven days after treatment. It is desirable to allow at least five to seven days before beginning a second course of $CaNa_2EDTA$.

See the following chart for recommendations concerning chelation therapy and $CaNa_2$ EDTA mobilization test.

## CHOICE OF MEDICAL MANAGEMENT BASED ON SYMPTOMS AND BLOOD LEAD CONCENTRATION.

| ASYMPTOMATIC CHILDREN<br>BEFORE TREATMENT, MEASURE VENOUS BLOOD LEAD | | |
|---|---|---|
| Clinical Presentation | Treatment | Comments |
| Class IIA -<br>Blood Pb-10 to 14 mcg/dl<br><br>Class IIB -<br>Blood Pb-15 to 19 mcg/dl | Pediatric evaluation<br>Monitor blood lead levels<br>Screen for iron deficiency | Provide counseling re appropriate nutrition and cleanliness - removal of paint chips and dust. |
| Class III -<br>Blood Pb 20 to 24 mcg/dl | Pediatric evaluation<br>Monitor blood lead levels<br>Screen for iron deficiency | Refer to local health department for environmental investigation.<br>Provide counseling regarding appropriate nutrition and cleanliness--removal of paint chips and dust. |
| Class III -<br>Blood Pb 25 to 44 mcg/dl | Pediatric evaluation<br>Monitor blood lead levels<br>Screen for iron deficiency<br><br>Perform $CaNa_2EDTA$ provocative test to assess lead excretion ratio (see text).<br><br>If ratio ≥ .60<br>$CaNa_2EDTA$ 1000 mg/m²/day<br><br>If ratio <0.60. No treatment<br><br>Succimer | Refer to local health department for environmental investigation.<br>Provide counseling regarding appropriate nutrition and cleanliness--removal of paint chips and dust.<br><br>Treat for 5 days IV or IM EDTA, as indicated in Class IV.<br><br>Repeat blood Pb and $CaNa_2EDTA$ provocative test periodically.<br><br>Some clinicians will use Succimer. (FDA approved with blood lead levels >45 mcg/dl). Physician should use clinical judgment. |
| Class IV -<br>Blood Pb 45 to 69 mcg/dl | Pediatric evaluation<br>Monitor blood lead levels<br>Screen for iron deficiency<br><br>Succimer: 10mg/kg or 350 mg/m² orally every 8 hours for 5 days. Reduce to 10 mg/kg or 350 mg/m² every 12 hours for an additional two weeks. Monitor liver function<br>or<br>$CaNa_2EDTA$ 1000 mg/m²/day | Refer to local health department for environmental investigation.<br>Provide counseling regarding appropriate nutrition and cleanliness - removal of paint chips and dust.<br><br>Emits a "rotten egg" sulfur odor.<br><br>Succimer is preferred unless compliance require use of $CaNa_2EDTA$<br><br>$CaNa_2EDTA$ for 5 days, preferably by continuous infusion, or in divided doses (through a heparin lock).<br>Other cycles may be needed depending on blood Pb rebound.<br><br>A minimum of 2 weeks between courses is recommended unless more prompt treatment is indicated. |
| Class V -<br>Blood Pb >70 mcg/dl | Pediatric evaluation<br>Monitor blood lead levels<br>Screen for iron deficiency<br><br>BAL 300 mg/m²/day<br><br>$CaNa_2EDTA$ 1000 mg/m²/day | Refer to local health department for environmental investigation.<br>Provide counseling regarding appropriate nutrition and cleanliness--removal of paint chips and dust.<br><br>Start with BAL 50 mg/m² IM every 4 hours.<br><br>After 4 hours, start $CaNa_2EDTA$ 1000 mg/m²/day, preferably by continuous infusion, or in divided doses IV (through a heparin lock).<br>Continue therapy with $CaNa_2EDTA$ for 5 days.<br>BAL may be discontinued after 3 days if blood Pb <50 µg/dl.<br>Other cycles may be needed depending on blood Pb rebound. |

**CHOICE OF MEDICAL MANAGEMENT BASED ON SYMPTOMS AND BLOOD LEAD CONCENTRATION.**

| SYMPTOMATIC CHILDREN | | |
|---|---|---|
| Clinical Presentation | Treatment | Comments |
| Class V - Acute encephalopathy | Pediatric evaluation<br>Screen for iron deficiency<br>Monitor blood lead levels | Refer to local health department for environmental investigation.<br>Provide counseling regarding appropriate nutrition and cleanliness--removal of paint chips and dust. |
| | BAL 450 mg/m$^2$/day | Start with BAL 75 mg/m$^2$ IM every 4 hours. |
| | $CaNa_2EDTA$ 1500 mg/m$^2$/day | After 4 hours, start continuous infusion of $CaNa_2EDTA$ 1500 mg/m$^2$/day.<br>Continue therapy with BAL and $CaNa_2EDTA$ for 5 days.<br>Interrupt therapy for 2 days.<br>Treat for 5 additional days, including BAL if blood Pb remains high.<br>Other cycles may be needed depending on blood Pb rebound. |
| Other symptoms | Pediatric evaluation<br>Screen for iron deficiency<br>Monitor blood lead levels | Refer to local health department for environmental investigation.<br>Provide counseling regarding appropriate nutrition and cleanliness - removal of paint chips and dust. |
| | BAL 300 mg/m$^2$/day | Start with BAL 50 mg/m$^2$ IM every 4 hours. |
| | $CaNa_2EDTA$ 1000 mg/m$^2$/day | After 4 hours start $CaNa_2EDTA$ 1000 mg/m$^2$/day, preferably by continuous infusion, or in divided doses IV (through a heparin lock).<br>Continue therapy with $CaNa_2EDTA$ for 5 days.<br>Discontinue BAL after 3 days if blood Pb <50 mcg/dl.<br>Interrupt therapy for 2 days.<br>Treat for 5 additional days, including BAL if blood Pb remains high.<br>Other cycles may be needed depending on blood Pb rebound. |

| Chelating Agents Used In Treating Children With Lead Poisoning | | | |
|---|---|---|---|
| **Product Name** | **Generic Name** | **Chemical Name** | **Abbreviation** |
| Calcium Disodium Versenate | Edetate disodium calcium | Calcium disodium ethylenediamine tetraacetate | $CaNa_2EDTA$ |
| BAL in Oil | Dimercaprol | 2, 3-dimercapto-1-propanol | BAL |
| Chemet | Succimer | Meso 2,3-dimercaptosuccinic acid | DMSA |

**$CaNa_2EDTA$ Mobilization (Provocative Chelation) Test**. This test identifies those children who will respond to chelation with a brisk lead diuresis (see Appendix C). The endpoint of this test is determined not by a lowering of the BPb level but by the amount of lead excreted per dose of $CaNa_2EDTA$ given. This ratio correlates well with BPb. In one study, almost all children with BPb ≥45 had positive provocative tests, 76 percent of children with BPb 35 to 44 mcg/dl had positive tests, and 35 percent of children with BPb 25 to 34 mcg/dl were positive (Markowitz and Rosen, 1991). Among children with BPb levels in the 25 to 44 mcg/dl range, this test is felt to be the most accurate predictor of who will benefit from chelation therapy.

**SUCCIMER (CHEMET)**. The Food and Drug Administration has approved Succimer for use in lead-poisoned children with blood lead levels >45 mcg/dl. The use of Succimer is not indicated for use with children having blood lead levels 70 mcg/dl or higher. Once a child's blood lead level reaches 45 to 69 mcg/dl, Succimer can be used. Succimer (trade name: Chemet), by McNeil Consumer Products Company, is a recently approved oral chelating agent effective in the treatment of lead poisoning. The route of administration allows the option of outpatient management of lead intoxication. The drug's specificity for lead substantially reduces the risk of essential mineral depletion associated with conventional parenteral chelating agents. The efficacy of this drug is comparable with other treatment modalities and may be superior in some situations. Succimer is a more efficacious chelating agent than EDTA in addition to being available in an oral form which is less toxic (see bibliography article by Graziano).

Indications and Usage

Succimer (Chemet) is indicated for the treatment of lead intoxication in children with blood levels above 45 mcg/dl. The drug is not indicated for the prophylaxis of lead poisoning in areas of high-risk exposure. Use of Succimer (Chemet) should always be accompanied by an active ongoing lead abatement program.

Dosage and Administration

Dosage should begin at 10 mg/kg or 350 mg/m$^2$ orally every 8 hours for 5 days. The dose should then be reduced to 10 mg/kg or 350 mg/m$^2$ every 12 hours for an additional two weeks. The total length of a single treatment course is 19 days. Repeated courses may be necessary if indicated by weekly monitoring of blood lead concentrations. A minimum of two weeks between courses is recommended unless blood lead concentrations dictate the need for more prompt treatment. Succimer (Chemet) is available in capsule form (100 mg) containing beads which can be mixed with food or fruit drinks for young children who cannot swallow the capsule whole The beads elicit a characteristic "rotten egg" sulfur odor due to the presence of the sulfhydryl moieties on the molecular structure. Doses should be rounded up or down to the nearest whole capsule increment when initiating therapy.

Monitoring Parameters

Baseline and post-chelation therapy blood lead concentrations are, of course, important parameters to follow in patients being treated with Succimer (Chemet). Lead level concentrations may rise following completion of chelation therapy due to redistribution of lead from bone stores. Succimer chelates are excreted in urine; therefore, adequate hydration is essential to maintain good urine flow. Serum transaminase should be obtained prior to initiation of treatment with Succimer (Chemet) and periodically thereafter.

**Summary**

**Clinical studies indicate that Succimer (Chemet) is a relatively selective and highly effective agent for the treatment of lead intoxication. Succimer (Chemet) reverses the metabolic effects of lead on heme synthesis while increasing urinary lead output. This novel orally active lead chelator offers the distinct advantage of outpatient treatment and subsequent lower health care costs for the persistent problem of lead poisoning.**

## FUTURE TRENDS IN THE MANAGEMENT OF CHILDHOOD LEAD POISONING

### BONE LEAD MEASUREMENTS USING X-RAY FLUORESCENCE (XRF)

The development of L-Line XRF techniques to measure tibial bone lead in children permits noninvasive assessments of skeletal lead levels and more accurately reflects the accumulated lead burden over an individual's lifetime. In contrast, BPb values reflect recent lead exposure and absorption during the past 1 to 3 months and provide only limited information about lead toxicokinetics over time. Endogenous release of lead from bone occurs and is the equivalent of new exposure. Knowing the toxicokinetics associated with endogenous release will add a new dimension to basic and clinical research. Evaluations using XRF methods have shown that BPb values may markedly underestimate the body burden of lead in lead-poisoned children. In one study, the majority of 59 lead-toxic children, with blood lead values between 23 and 53 µg/dl, had bone lead values equal to those measured in industrially exposed adults. Hence, by aged 7 years, lead-poisoned children may have remarkably elevated skeletal burdens of lead, which may exert profound effects on their health in later years. The L-line technique has also documented decreases in bone lead content sequentially following $CaNa^2EDTA$ treatment in lead-poisoned children.

When considering published data concerning radiation dosimetry, counting time, minimum detection limits, and clinical data in lead-paint poisoned children, the L-line XRF technique appears to be the most valuable technique for epidemiological and clinical analyses of infants, children, pregnant women, and women of child-bearing age. For studies of industrial workers and post-menopausal women, the K-line XRF method appears most appropriate. Together, these XRF methods will be valuable tools for studying the association between bone lead concentration and renal disease, hypertension, and adverse effects on the central nervous system. L-line XRF, measuring lead over longer exposure periods, will be increasingly incorporated into management and treatment protocols. At present, the availability of XRF equipment is limited to a few centers in the United States and Europe.

## TREATMENT AND FOLLOW-UP

### POST CHELATION FOLLOW-UP

**Recheck blood lead levels 7 to 21 days after treatment.**

**Determine if retreatment is necessary.**

**Do not discharge a child from the hospital until a lead-free environment can be assured.**

At the end of each treatment cycle, the BPb concentration usually declines to values <25 mcg/dl. Within a few days, however, reequilibration among body lead compartments takes place and may result in a rebound; thus, the BPb level must be rechecked 7 to 21 days after the end of treatment.

In children who have received chelation therapy, repeated cycles are indicated if the blood lead concentration rebounds to within 5 mcg/dl of the original pretreatment value 7 to 21 days posttreatment. In all children, regardless of age, with elevated BPb lead values but with an excretion ratio less than 0.60 on the provocative chelation test, BPb should be measured monthly. If the elevation in BPb values persists, the $CaNa_2EDTA$ provocative test can be repeated periodically (every one to three months) and interpreted according to the above guidelines.

Any child who undergoes chelation treatment requires long-term follow-up preferably from pediatric health care providers, nutritionists, environmental specialists, and community outreach workers. The last group provides a critical bridge among hospital-based or clinic-based (outpatient) medical care, health advocacy education, and environmental remediation outside the hospital. **A child should not be discharged from the hospital until appropriate alternative housing is provided while all lead hazards in his/her home or elsewhere are being controlled and eliminated. Lead free "safe housing" (with friends, relatives, or in designated transitional housing) must be arranged in which a successfully treated child can live with his/her family during the entire abatement process through post-abatement clean-up.** With appropriate public health measures, complete and safe abatement should take place during the treatment period.

Once a child is discharged to a safe environment, frequent follow-up is mandatory. In general, depending on the initial BPb value, most children who require chelation therapy must be followed closely for at least one year or more until the BPb and EP concentrations reach values <25 and 35 mcg/dl, respectively. **All children undergoing chelation treatment should be seen every other week for eight weeks, then once a month for six months. A child treated with BAL and $CaNa_2EDTA$ should be followed more closely: every two weeks for six weeks, then monthly for 12 months.**

With prompt diagnosis, removal from lead sources and chelation therapy (when indicated), the toxic biochemical effects of lead may be reversible; the reversibility of these indices has been shown to follow different time courses. The return to normal EP concentrations (35 mcg/dl) takes several weeks to several months. The gradual decline that should occur in EP values (with successful environmental and medical intervention) is a valuable parameter to follow post-treatment. Successful chelation treatment, coupled directly with elimination of lead hazards, should reduce BPb and EP values to <25 mcg/dl and <35 mcg/dl, respectively. Return of BPb to <25 mcg/dl and EP to <35 mcg/dl has been considered the end-point of successful medical management.

At each clinic visit, environmental and housing information should be updated. Re-evaluation of the environment may be necessary (preferably by an environmental specialist from the local health department who plays a central role to ensure prompt, safe and technically sound abatement). Nutritionists can provide nutritional advice and assist in managing neurobehavioral disorders. Continued improvement in serial BPb and EP data indicate no excessive new exposure to lead; rising BPb concentrations, which may be accompanied by a rising EP level, indicate increased exposure to lead. Reinvestigation often reveals previously undetected sources of environmental lead, inadequate abatement, or unsound structures in buildings (poor plumbing with leaks).

A comprehensive developmental evaluation, including a hearing screen, should be conducted yearly on any child with lead poisoning. The children need evaluation for problems such as attention deficit disorders and behavioral problems, as well as lowered IQ or obvious neurologic or learning problems. Appropriate early intervention or early childhood services and counseling of parents should be provided as necessary. Early intervention agencies or the early childhood programs of public school districts and Head Start programs should be used for developmental screening and monitoring of neurobehavioral status.

When a child with earlier elevated BPb concentrations approaches school age, psychometric evaluation may be indicated, even though the blood lead concentration at the time is <20 mcg/dl.

## ROLE OF THE DEPARTMENT OF PUBLIC HEALTH

Lead poisoning requires a coordinated approach. Cases are found by doctors and nurses providing routine health care. Screening teams from local health departments also visit high-risk neighborhoods. The state Division of Laboratories provides testing of blood samples.

The Illinois Department of Public Health (IDPH) has a Case Registry for reported cases of childhood lead poisoning in children younger than aged 16. Follow-up data on intervention, treatment, child's developmental status, source of lead and abatement is collected as part of the surveillance system. This surveillance system is used to develop public policy regarding childhood lead poisoning.

When IDPH designates a child as a case, a local public health team should intervene. A public health nurse initiates contact to determine whether the child is receiving appropriate intervention and medical treatment. A licensed investigator from the local health department, if available, will inspect the home for sources of lead. The owner of the building will be ordered to correct (abate) the hazards. If the owner does not comply, the State's Attorney's Office will prosecute.

Public health nurses or community workers may follow families on a long-term basis, advising them about nutrition and avoidance of lead, and expediting compliance with medical care. While proper nutrition alone does not lower lead levels, it reduces absorption. As calcium and iron levels go up, lead absorption drops.

Medical treatment alone will not help a poisoned child. He must be released to a safe environment which is lead free.

The Department of Public Health has identified physicians willing to act as medical consultants on any issues relating to screening, evaluation, diagnosis, clinical management, or treatment of lead poisoning, or to discuss any unusual cases that pose problems for clinicians. Physicians who would like to confer with a medical consultant should contact the Childhood Lead Poisoning Prevention Program at **(217) 782-0403**. Toxicon, a toxicology consortium, combining the resources of the Rush Poison Control Center, the Cook County Hospital Section of Clinical Toxicology and the University of Illinois Drug Information Center, can be contacted for patient related calls at **(312) 942-5969**.

## COMMUNITY INTERVENTION

Local health officials who have traditionally carried out all or most of the lead poisoning prevention activities in a community will work in collaboration with physicians and other education, social service and housing agencies that have a role in community-wide primary prevention efforts. Lead poisoning prevention strategies will work best as part of an integrated program for creating safe and affordable housing and/or providing poor people in the community with the full range of needed social services. Local, state, and federal agencies dealing with health, housing, environmental, and children's issues should be identified and contacted. Optimally, a regular, formal mechanism should be established for communication among agencies and decision-making on joint prevention strategies.

To be successful, community-level intervention will require four types of activities:

1. Surveillance and Risk Assessment: Determining populations at risk and areas where the most exposures are occurring.

2. Outreach and Education: Informing health care providers, parents, day care providers, early childhood educators,

property owners, and other key audiences about lead poisoning prevention.

3. Infrastructure Building: Creating the resources needed for a successful program of risk abatement.

4. Hazard Abatement: Abating the hazards of lead paint, dust and soil, particularly in high-risk buildings and neighborhoods.

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# APPENDIX A

## SPECIMEN COLLECTION

Blood lead determinations on microspecimens collected by capillary measures are widely performed, however microspecimens are subject to contamination with environmental lead. The high potential for lead contamination of capillary specimens during collection is well known, and the special steps used to minimize contamination constitute the major differences among collection procedures. Special procedures used for minimizing contamination include thorough scrubbing of the hand and finger with soap and then alcohol.

Several types of pediatric blood collection containers (maximum volume ≤500 uL) have been introduced in recent years and are widely used by screening programs. The new containers offer advantages over glass capillary tubes in terms of safety. (Glass capillary tubes are very fragile.)

Materials used in the collection procedures that have the potential for contaminating the specimen (e.g., blood container, alcohol swabs, barrier spray) must be lead-free. The State Laboratory will recommend or supply suitable collection materials.

### PREPARING FOR BLOOD COLLECTION

All personnel engaging in specimen collection should be well-trained and thoroughly familiar with the collection procedure. The skill with which any collection procedure is performed will greatly influence overall specimen quality.

# APPENDIX B

## QUESTIONNAIRE TO DETERMINE RISK

Name:_____ Date of Birth:_____

| Date | / / | | / / | | / / | | / / | | / / | | / / | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Does your child --- | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No | Yes | No |
| 1. Live in or regularly visit a house with peeling or chipping paint built before 1978? This could include a day care center, preschool, home of a baby sitter, a relative, etc. | | | | | | | | | | | | |
| 2. Live in or regularly visit a house built before 1978 with planned or ongoing renovation or remodelling? | | | | | | | | | | | | |
| 3. Have a brother or sister, a housemate, or a playmate with confirmed lead poisoning? | | | | | | | | | | | | |
| 4. Live with an adult whose job or hobby involves exposure to lead? | | | | | | | | | | | | |
| 5. Live near an active lead smelter, battery recycling plant, or other industry likely to release lead? | | | | | | | | | | | | |
| If yes to any of these questions, children should be screened for lead poisoning. | | | | | | | | | | | | |

## APPENDIX C

## THE EDTA MOBILIZATION TEST

PURPOSE, INDICATIONS:

To identify those children with significant lead burdens which may be mobilized with $CaNa_2EDTA$. Ideally reserved for those with PBb between 25 mcg/dl and 44 mcg/dl.

CONTRAINDICATIONS:

Pre-existing renal disease.

PROTOCOL:

I. Establish an intravenous line of $D_5$1/4 normal saline.* Administer a 10 ml/kg bolus over 15-20 minutes.

II. If not toilet-trained, attach an adhesive urine bag to the perineum.

III. Infuse $CaNa_2EDTA$ 25 mg/kg in 150 ml $D_5$1/4NS over 30-45 minutes.

IV. Continue administration of $D_5$1/4NS at 1.5 times hourly maintenance rate after EDTA infusion is complete.

V. Collect all urine for 8 hours into a lead-free container. The beginning of the urine collection should coincide with the administration of the $CaNa_2EDTA$.

VI. Analyze urine collection for total lead, total volume, creatinine.

VII. The mobilization test result is defined by the ratio of lead excretion (in ug) divided by the total EDTA dose (in mg). A ratio of $\geq 0.6$ is considered positive and suggests benefits from further doses of EDTA.

VIII. If mobilization ratio is $<0.6$, consider a repeat mobilization test after iron supplementation (if child was iron deficient). If ratio is negative in the face of adequate iron stores, consider alternative therapies.

IX. Specify urine collection as complete or incomplete. For incomplete collections, a urinary lead concentration of $\geq 1.0$ µg/ml has a positive predictive value of .85 in identifying children with positive mobilization tests.

*Mobilization Test may be performed with intramuscular injection of EDTA followed by liberal oral fluid intake. Add crystalline procaine for pain control.

First, a repeated baseline BPb level must be obtained and the patient is asked to empty the bladder. Then $CaNa_2EDTA$ is administered at a dose of 500 mg/m$^2$ in 5% dextrose infused over one hour. (A somewhat painful but practical alternative is to administer the same dose intramuscularly mixed with 0.5% procaine). All urine must be collected with lead-free equipment over the next eight hours.[1] In the laboratory, the urine volume should be carefully measured and stored at 20°C until the lead concentration is measured. Extreme care must be taken to ensure the use of only lead-free equipment.

The use of "lead-free" apparatus for urine collections is mandatory to obtain valid test results. The laboratory performing the analysis should supply the proper collection apparatus. Preferably, urine should be voided directly into polyethylene or polypropylene bottles by the usual procedures, then washed in nitric acid, and thoroughly rinsed with deionized, distilled water. For children who are not toilet trained, plastic pediatric urine collectors can be used. Urine collected in this manner should be transferred directly to the urine collection bottles.

Interpretation of $CaNa_2EDTA$ Provocative Test. The concentration of lead in the urine (in micrograms per milliliter) is multiplied by the total urinary volume (in milliliters) to obtain the total excretion (in micrograms). The total urinary excretion of lead (micrograms) is divided by the amount of $CaNa_2EDTA$ given (milligrams) to obtain the "lead excretion ratio":

$$\frac{\textit{Lead excreted (mcg)}}{\textit{CaNa}_2\textit{EDTA given (mg)}}$$

An eight-hour $CaNa_2EDTA$ provocative test is considered positive if the lead excretion ratio is >0.60.

Guidelines for Treatment Based on the $CaNa_2EDTA$ Provocative Test. For a BPb range between 25 and 44 mcg/dl and a lead excretion ratio that exceeds 0.60, a five-day course of $CaNa_2EDTA$ (1000 mg/m$^2$ intravenously) should be given to all children.

[1]An eight-hour mobilization test has been shown as reliable as a 24-hour mobilization test (Markowitz and Rosen, 1984). An eight-hour test can be accomplished on an outpatient basis, but the patient should not leave the clinic during this test.

## APPENDIX D

## PREVENTION OF LEAD POISONING
Advice to Parents

LEAD PAINT. Intact paint is not a hazard to your child, but peeling paint and paint dust is a danger.

Most homes built before 1950 contain lead paint and about half of houses built between 1950 and 1980 are likely contain lead paint.

1. Check your home inside and out for peeling paint, looking especially around wooden door and window frames, where weather and friction tend to grind and chip painted surfaces.

2. Clean up any peeling paint and cover peeling areas of so your child cannot touch them until they are repaired.

3. To prevent your children eating dust contaminated with lead wet mop wooden and tile floors, wash the toys of young children, and wash children's hands before they eat.

4. You can determine if lead paint is present by using a do-it-yourself lead testing kit or by contacting your county or state health department to get a referral to a professional contractor or laboratory to test for lead. Home test kits are sold by:

   Frandon Enterprises, 511 N. 48th St., Seattle, WA 98103, 1-800-359-9000

   HybriBet Systems, Inc., P.O. GBHox 1210, Framingham, MA 01701, 1-800-262-LEAD

5. **It is very dangerous to attempt to remove lead paint yourself since you need protective devices to prevent inhalation of lead dust, and the home needs to be carefully sealed to prevent spreading of lead dust. Regular vacuums tend to spread rather than contain the dust. Scraping and sanding paint are dangerous, and heating lead paint with torches is very dangerous since it vaporizes the lead so that it is easily inhaled. For guidelines that should be followed in removing lead paint, contact:**

   **Division of Environmental Health**

**Illinois Department of Public Health**
**525 West Jefferson St.**
**Springfield, Illinois 62761**
**217/782-5830**

SOIL: Soil gets contaminated with lead from paint washed off of buildings, automobile exhaust, and emissions from local industry.

1. Try to find play areas away from old painted buildings or provide your child with a covered sandbox.

2. Make sure your children wash their hands before they eat after playing outside.

DRINKING WATER: Water may be contaminated by lead solder used to connect your plumbing to the water main.

The new safe standard for lead content of water is 15 ppb (parts per billion).

1. You can get your drinking water tested by calling the EPA's water safety hotline at 1-800-426-4791 for a list of state-certified testing laboratories. If your water's lead content is more than 10 to 15 ppb, do the following:

2. Before you draw water for drinking or cooking, run the cold water for 1 to 2 minutes if the taps have been turned off for more than six hours. Keep a pitcher of cold water in the refrigerator.

3. Always use cold water for drinking and cooking. Hot water contains more lead.

DISHWARE AND CANNED FOOD: Some of the lead in the glazes on pottery and china may not be properly fired during manufacture and may leak into food or solutions such as fruit juices or coffee.

1. You can use the containers for serving, but do not use them to store foods or beverages. Likewise, do not store liquor in crystal decanters.

2. Lead solder is no longer used in most tin cans made in the United States but is still used in canned foods from some other countries.

NUTRITION: Iron or calcium deficiency promotes <u>increased absorption</u> of lead from the intestines.

Therefore, be sure your child has enough iron and calcium in the diet.

## APPENDIX E

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