PedsCases Podcast Scripts

This podcast can be accessed at www.pedscases.com, Apple Podcasting, Spotify, or your favourite podcasting app.

LEAD EXPOSURE IN CHILDREN

Developed by Mikayla Gray and Dr. Abbeir Hussein for
PedsCases.com.
December 1, 2021

Introduction

Hello and welcome to the PedsCases podcast on chronic, low-level lead exposure in children.

My name is Mikayla Gray and I am a third-year medical student at the University of Alberta. This PedsCases podcast will aim to provide the listener with an appreciation for the importance of recognizing and preventing lead exposure in children, a relatively rare but important condition included on many differential diagnoses. This podcast discusses a recent CPS practice point titled “Lead toxicity with a new focus: Addressing low-level lead exposure in Canadian children.” For additional information and to view the complete practice point, please see cps.ca.

This podcast was created in collaboration with Dr. Abbeir Hussein, a pediatrician and practitioner at the Children’s Environmental Health Clinic in Edmonton. I would also like to acknowledge Drs. Irena Buka and Chris Novak for their input and edits.

The learning objectives for this podcast are to:

1. Learn about the long-term health consequences of chronic low-level lead exposure and how children can be exposed to lead;
2. Understand the presentation of a child with suspected lead exposure;
3. Gather history, perform an appropriate physical exam and recognize investigations used for suspected pediatric lead exposure;
4. Develop an approach to the management of pediatric lead exposure; and
5. Recognize the vital importance of primary prevention of lead exposure.

Acute, overt lead poisoning is very rare in Canada and is beyond the scope of this podcast.

Rock on team, we’re about to dive into some heavy metal!

Case

Let's begin with a clinical case.

Ming Fai is a 6-year-old boy who has come to see you with his mother, Mei Ling. Mei Ling is concerned with his cognitive development. The family immigrated from Guiyu, China almost a year ago. His parents and teachers have reported that he struggles with reading in both English and Cantonese, and also has difficulties with math. With Mei Ling's approval, the school performed an IQ test for Ming Fai and he got a score of 63, which would be consistent with a diagnosis of intellectual disability. Ming Fai is not taking any medications and there is no family history of developmental delay. On social history, Mei Ling admits that due to financial constraints, she sometimes struggles to purchase as many fresh fruits and vegetables as she wishes she could provide for her family. On top of this, Ming Fai is also a picky eater and she has noticed that he has recently taken to eating paint chips off of the wall in the basement. With a little more questioning, you find out that both Mei Ling and Ming Fai's father, Wing Hong, work at the local battery manufacturing facility. The three of them live together in a lower income community, in a house that was built in the 1940's. Mei Ling is unsure if Ming Fai's behaviour is normal and doesn't know what to do. She asks you what testing he needs and what the next steps are.

This is a lot of information to take in and there are various diagnoses to be included on the differential. Let's dive into some more information on chronic, low-level lead exposure before continuing with the case.

Background

Lead is a heavy metal characterized by its natural abundance in the Earth's crust and its malleable nature. Once inside of the human body, lead can mimic calcium ions, thereby allowing it to enter the brain, as well as bone. In the brain, lead can alter the activity of neurons and cause significant neurodevelopmental challenges. It is estimated that 3.5% of mild intellectual disability worldwide is caused by lead exposure. Chronic accumulation in bone presents a problem for growing children as bone is constantly being built and resorbed throughout development.

Overt lead poisoning from acute and subacute exposures is relatively rare in Canada due to various public health measures taken in the late 20th century. This includes banning the sale of leaded paint and gasoline, however, one still needs to be aware of the potential for and harms of chronic, low-level lead exposure.

The danger with chronic, low-level lead exposure is that there is a latency period between exposure and the appearance of symptoms. In many cases, symptoms can be

quite subtle and evolve slowly over time. Newer research shows poor health consequences at lower blood lead levels (BLL) than previously thought. The currently accepted cut off for concern and investigation is 5 µg/dL, however it is important to note that there is no safe level of lead exposure for children.

Although adults can also become exposed to lead, children are of particular concern for three reasons. Firstly, children are able to absorb more lead into their bodies given the same exposure and can absorb up to 40% of what they were exposed to. Secondly, 70% of this absorbed lead is stored in bone and can be re-released into the blood during bone growth and remodeling, which happens much more frequently in children and adolescents than in adults. And thirdly, children are also still undergoing neurodevelopment. Thus, lead interference with neurodevelopment has the potential to cause severe, life-long consequences for children.

Children can become exposed to lead in a variety of ways, and those under the age of 3 years are at the highest risk for exposure and an elevated BLL. Ingestion and absorption in these first few years of life are variable and peak around 36 months of age, often coinciding with the onset of increased mobility and hand-mouth behaviour. If you've ever met a child less than 3, you probably know that they love to put things in their mouths! During this time, oral ingestion, inhalation and dermal absorption are the main routes of lead entry into the body. Lead can also affect the fetus during pregnancy if the mother were exposed.

Sources of lead exposure include contaminated dust and soil, water and various consumer products.

Let's start with dust and soil, which is the largest category of exposure. A large contributor to this category is leaded paint, which is most commonly identified in homes built before 1978, but especially before 1960. Chipping paint can contaminate house dust and outdoor soil, and is especially prominent in windows and doors, where paint is more likely to be disturbed. Additionally, communities located close to current or former industrial sites such as recycling facilities or battery smelters are at risk of lead-containing industrial pollution to have been deposited onto nearby soil. Homes located in close proximity, that is within 4km, of a major roadway are also at risk of lead deposits in soil due to the past use of leaded gasoline. Finally, it is important to recognize where lead-containing dust may be tracked into the home from elsewhere. For example, parental occupation can play a large role in this. Parents who have occupations such as mining, pipe-fitting, construction, welding, plumbing, battery manufacture, auto repair or painting are potentially able to track lead particles into the home. Now, considering children at play on the floor, or on the ground outdoors, it is easy to imagine how some of this soil and dust can be ingested or inhaled.

Developed by Mikayla Gray and Dr. Abbeir Hussein for PedsCases.com.
July 7, 2021.

Water is another possible source of lead exposure. This is mainly an issue for children consuming tap water that is originating from older plumbing systems that still contain leaded pipes and service lines. Without the proper anticorrosive treatments, corrosion in these systems can lead to lead leaching and water contamination.

The last category of exposure is from consumer products such as food, especially game meat killed with leaded ammunition, toys and some cosmetic products. This is a large topic and will not be discussed here in detail, but remember it is important to inquire into these issues if other lead sources are not identified. Canada generally has regulations on the maximum amount of lead content products can have, but unless explicitly asked, one can never know for certain where some products originate from. Other countries may have more lax regulations and some products may be imported.

Children with deficiencies of iron, calcium and zinc are at higher risk of lead toxicity. These ions have shared pathways for absorption in the GI tract. For example, lead and iron share the same binding protein and this protein is upregulated in iron deficiency. If a child with iron deficiency is exposed to lead, they are then going to absorb more of it into their bloodstream.

Knowing these sources of lead exposure, remember that the home is not the only place where children spend their time. One should also consider the day care or school that they are attending, if there is another home they visit frequently, and the outdoor areas they often visit such as playgrounds.

Now, knowing how lead can enter the body, we can identify groups that are at higher risk. Children that are at particularly high risk of exposure therefore include any patient identified to have a neurodevelopmental disorder plus any of the following, including:

- residence in a home built before 1960, especially if it still contains leaded paint and plumbing systems;
- those living in poverty or of low SES;
- those exhibiting pica behaviour, which is the eating of non-food items such as paint chips, dirt, hair, ice and paper. This can be seen as a symptom of iron-deficiency anemia in children;
- newcomers to Canada, especially from an area where population BLLs are known to be higher, such as in Southeast Asia, and;
- children with a sibling or playmate who have a history of lead poisoning.

Now that we've discussed more about how lead exposure can occur and who is at risk, how will we approach our patient, Ming Fai?

Developed by Mikayla Gray and Dr. Abbeir Hussein for PedsCases.com.
July 7, 2021.

Approach to Investigating Suspected Chronic Low-Level Lead Exposure: History, Physical Exam and Lab Investigations

A clinician might suspect lead exposure either from suggestive symptoms, risk factors or from known exposure, such as when another member of the household has an elevated BLL.

The symptoms, if any, of chronic low-level lead exposure are subtle and may be latent. Neurologic manifestations include cognitive delay, inattention, hyperactivity, poor balance and speech delay. Other possible symptoms include hearing loss, renal disease, abdominal symptoms and microcytic anemia. Each of these symptoms has a broad differential, but you may consider lead toxicity if there are other risk factors present.

In addition to symptoms, one should inquire about nutrition. Deficiency in calcium, zinc and iron are associated with lead toxicity. You should ask about pica, as these children are at higher risk of ingesting lead (and many other things!).

If there is an index case for another household member, meaning they've been identified to have a BLL over 5 µg/dL, then one should perform the Pediatric Environmental Health History for the patient and other household members. This template was developed by the World Health Organization and can be found on their website (https://www.who.int/ceh/capacity/green_page_en.pdf?ua=1). It covers potential biological, chemical and physical environmental hazards and their sources as well as where, when and how children are exposed. It also identifies clinical and subclinical effects of exposure in utero, postnatally, and in children of various ages.

On physical exam, the most important exam for suspected lead exposure is the detailed neurodevelopmental exam. "Lead lines" between the teeth and gums may also be observed in cases of chronic, severe exposure.

In terms of lab investigations, the most important test to order is the venous blood lead level (BLL). It is important, however, to bear in mind that this assay is not useful unless there has been a *recent* exposure. The half-life of lead in blood is 45 days, after which most of it is stored in bone. Therefore, the BLL is the gold standard for diagnosis of *recent* lead exposure. Concern is raised if the BLL is equal to or higher than 5 µg/dL (or 0.24 µmol/L). A BLL below this threshold, however, does not rule out lead exposure as a contributing factor to symptoms, especially if there has been no previous BLL documentation.

Other investigations to order should include a CBC as well as ferritin, calcium, protein and albumin levels. Severe lead toxicity can lead to dense metaphyseal bands which

can be seen on long-bone X-rays. While these are a good topic for pimping on the wards, they are really only seen with high levels of lead exposure, and long-bone X-rays are not routinely recommended by organizations such as the CDC.

Back to the Case

Let's get back to our case. Now that we know more about how lead exposure can happen, we can see that Ming Fai has multiple risk factors that would make him a candidate for potential lead exposure. To name a few, he recently immigrated from an area known to have high population BLLs, he exhibits pica behaviours, his parents work in a high-risk industry and he lives in a home built before 1960. His presentation suggests possible intellectual delay, and this combined with his risk factors are an indication to consider lead exposure as the cause. Our first step is to order Ming Fai's BLL and associated lab investigations to rule this out.

Ming Fai's lab results return and indicate his BLL to be 6.2 µg/dL. His ferritin is slightly low and all other results are normal. How should we approach Ming Fai's management?

Management of Lead Exposure

Treatment of lead exposure can be complicated and depends on the BLL detected. For any BLL over 5 µg/dL, the Pediatric Environmental Health History should be completed to identify sources of exposure. The most important step to then take is to reduce and remove these sources as much as possible. Another very important step is to ensure optimization of nutrition to reduce lead absorption and promote healthy development. The focus here is on prevention of further exposure, as the neurocognitive effects of lead exposure cannot be reversed. For Ming Fai, it is recommended that he focus on iron-rich foods such as meats, legumes and leafy green vegetables to ensure he gets enough iron and calcium. Supplementation may be needed. Professionals should assess the age of his home, and look for lead sources such as leaded paint and soil contamination, which should be removed if found. Finally, recall that Wing Hong and Mei Ling both work at the local battery manufacture site. While it is not feasible in most cases to request a change in occupation, recommendations should be made about ensuring that as much as possible, they do not track dust from work into the home. This may include a change of clothing at work, handwashing and keeping work materials out of Ming Fai's reach.

Ming Fai should have his BLL re-evaluated within 1-3 months, and again 3 months after that to ensure it is stable or decreasing. Complete neurodevelopmental assessments should be made at every visit with close follow up. He would benefit from a referral to speech language pathology, and developmental pediatrics in support of his intellectual

disability. You could also work with the school to develop an individualized program plan for his learning needs.

Had Ming Fai's BLL been elevated above 15 µg/dL, more severe intervention may be required. His BLL would need to be re-evaluated within 1 month and x-rays may be necessary to assess bone health. Gut decontamination may be needed as well.

Had his BLL been elevated to above 44 µg/dL, this would've been a case of acute lead exposure requiring immediate chelation therapy. Further discussion of severe lead toxicity is beyond the scope of this podcast.

Whew! The hard parts are done. We will wrap up with a word on prevention and a quick summary.

Prevention

The importance of prevention of lead exposure cannot be over-stated enough. Once lead enters bone, there is no treatment to remove it and, as I hope you've learned by now, the consequences of recurrent exposure can be severe. The societal cost of childhood lead exposure is substantial. In the US, a cost-benefit ratio of investing in safer housing to prevent lead exposure is estimated to be similar to that for childhood vaccination!

Various strategies have been employed to identify children with elevated BLLs. Screening programs can be helpful to identify cases earlier, however, only identify children who've already been exposed. The most reliable and effective method is primary prevention, so that children are not exposed in the first place.

Primary prevention involves reducing sources of exposure. Health professionals and governments should advocate for and work together to enforce strict controls on the levels of lead in drinking water, food, air and consumer products. Industrial sites should be held accountable for reducing toxic waste that may contain lead. Older housing units should be adequately tested for safety prior to occupancy or renovation (which may disrupt leaded paint). Finally, patient education is also important, however, guidance regarding dust control and hand-washing alone have proven to be ineffective in reducing BLLs.

Summary

In summary, chronic low-level lead exposure is a vital issue to many children around the world and in Canada. Recognizing and preventing exposure are key to ensuring healthy bone and neurodevelopment. To conclude this podcast, let's review a few key points:

1. There are multiple ways in which children can become exposed to lead. These exposures accumulate over time and can lead to long-term health consequences;
2. Some of the most devastating consequences of lead exposure in children are non-reversible neurodevelopmental effects. These children may present with difficulties in memory, learning, speech and balance. Remember, if there are risk factors present, lead exposure should be on your differential;
3. The BLL is a blood test to quantify *recent* lead exposures and a BLL <5 µg/dL does not rule out lead exposure. Clinical suspicion is of high importance;
4. Lastly, primary prevention of lead exposure is key. Families don't always have an abundance of options in terms of occupation, housing and food, so advocating for a reduction in exposures in a way that will work for your patient and their family is vital.

This now concludes this podcast discussing the recent CPS practice point on low-level lead exposure in Canadian children. I would like to extend a special thanks to Dr. Hussein for her support of this podcast. Thank you for listening!

Developed by Mikayla Gray and Dr. Abbeir Hussein for PedsCases.com.
July 7, 2021.

References

1. Buka I, Hervouet-Zeiber C. Lead toxicity with a new focus: Addressing low-level lead exposure in Canadian children. Pediatrics and Child Health. 2019; 24(4):293.
2. American Academy of Pediatrics Council on Environmental Health. Prevention of Childhood Lead Toxicity. Pediatrics. 2016; 138(1):e20161493.
3. World Health Organization. The paediatric environmental history: Recording children's exposure to environmental health threats: A "green page" in the medical record [Internet]. Accessed 2020 December 30. Available at: https://www.who.int/ceh/capacity/paedenvhistory/en/#:~:text=Taking%20the%20paediatric%20environmental%20history,relevant%20to%20a%20child's%20health.
4. Huo X, Peng L, Xu X, Zheng L, Qiu B, Qi Z, Zhang B, Han D, and Piao Z. Elevated blood lead levels of children in Guiyu, an electronic waste recycling town in China. Environmental health perspectives. 2007; 115(7):1113–1117.
5. Min-ming L, Cao J, Gao Z, Shen X and Yan C. The trend of lead poisoning rate in Chinese population aged 0–18 years old: a meta-analysis. BMC Public Health. 2015; 15:756.
6. Pivalizza P and Lalani S. Intellectual disability in children: Definition, diagnosis and assessment of needs. UpToDate. Accessed 2021 January 26. Available at: https://www.uptodate.com/contents/intellectual-disability-in-children-definition-diagnosis-and-assessment-of-needs?search=iq%20score&source=search_result&selectedTitle=3~150&usage_type=default&display_rank=3#H385880598
7. American Academy of Pediatrics: Committee on Environmental Health. Screening for Elevated Blood Lead Levels. 1998. Accessed 2021 January 26. Available at: https://pediatrics.aappublications.org/content/pediatrics/101/6/1072.full.pdf?ck=nck
8. Belanger S and Caron J. Evaluation of the child with global developmental delay and intellectual disability. Pediatrics and Child Health. 2018; 23(6):403-410.

Developed by Mikayla Gray and Dr. Abbeir Hussein for PedsCases.com.
July 7, 2021.