Transcript: Clinician Overview: Arsenic

Slide 1: Clinician Overview: Arsenic

Clinician Overview of Arsenic

Slide 2: Goals for this Presentation

The Agency for Toxic Substances and Disease Registry, or ATSDR, developed this presentation to familiarize healthcare providers with the health effects of arsenic; provide information about clinical evaluation and patient management; and to discuss prevention strategies.

Slide 3: Learning Objectives

This presentation will cover properties of arsenic and its sources in the environment, routes of exposure, populations at risk for exposure, and potential health effects from exposure. We will also discuss clinical evaluation and management of patients exposed to arsenic, including appropriate follow-up, counseling, and exposure-reduction strategies.

Slide 4: Properties

To begin, we will review the properties of arsenic.

Slide 5: Properties of Arsenic

Arsenic is a naturally occurring element that is widely distributed in the Earth's crust. It is found in soil, mineral ores, groundwater, volcanic eruptions, and seafood. It is also used in many industrial processes, including metal smelting, wood preservation, and arsenical pesticide production and application. Arsenic is usually found in the environment combined with other elements and is commonly classified as inorganic or organic arsenic. Most inorganic and organic arsenic compounds are white or colorless powders that do not evaporate. They have no smell, and most have no particular taste. Inorganic arsenic compounds are highly toxic and contain non-carbon elements such as oxygen, chlorine, and sulfur. Organic arsenic compounds contain carbon and are generally less toxic than inorganic arsenic.

Slide 6: Sources of Arsenic

Next, we will review the sources of arsenic.

Slide 7: Sources

Arsenic is found in a wide range of products and materials. Because arsenic is a natural component of the Earth's crust, it exists in the air, water, and soil. Both human and natural activity can release arsenic into the environment. Human activities that release arsenic into the environment include mining, metal smelting, and other industrial operations.

Inorganic arsenic can be found in crops such as rice, corn, fruits, and vegetables that are grown in contaminated soil or irrigated with contaminated water. As a result, it may be found in meat

from animals that consumed these types of crops or drank contaminated water. It is also used industrially as an alloying agent, in the tanning of hides, and in the processing of glass, pigments, textiles, paper, metal adhesives, wood preservatives, and ammunition. Inorganic arsenic-based pesticides were once widely used for a variety of agricultural and home applications. However, they were discontinued for most uses in the United States during the 1980s and 1990s. Today there are limited permitted uses of pesticides containing monosodium methanearsonate, or MSMA, an organic arsenical that is converted into inorganic arsenic in the environment. Some traditional, imported, homeopathic, and naturopathic remedies can contain arsenic. Seafood naturally contains arsenobetaine and arsenocholine, which are organic forms of arsenic that are essentially nontoxic. However, shellfish in contaminated bodies of water can also contain inorganic arsenic.

Slide 8: Routes of Exposure

Next, we will cover routes of exposure.

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Exposure can occur via ingestion, inhalation, and dermal absorption.

Slide 10: Routes of Exposure: Ingestion

For the general U.S. population, the main source of arsenic exposure is ingestion of food containing arsenic. Food can contain inorganic and organic forms of arsenic. Seaweed, rice, fruits, meat, shellfish, and poultry are potential dietary sources of inorganic arsenic. Seafood, particularly finfish, contains mostly nontoxic organic arsenic and is unlikely to be a cause of arsenic toxicity. The U.S. Environmental Protection Agency, or EPA, has set a drinking water standard of 10 micrograms of arsenic per liter of water. This standard is based on total arsenic, but drinking water contains almost entirely inorganic forms.

Chromated copper arsenate, or CCA, is a wood preservative that was previously used in residential structures such as playgrounds. Arsenic can leach from CCA-treated lumber into soil, and children with mouthing behaviors during play are at risk for arsenic exposure. Because of this risk, in 2003 the EPA and the lumber industry agreed to discontinue the use of CCA-treated wood in most residential construction.

Slide 11: Routes of Exposure: Inhalation

Inhalation can also be a route of exposure.

Inhalation of particulate matter from burning arsenic-containing wood or coal can be a significant route of inhalational exposure. Larger particles are deposited in the upper airways and swallowed after coughing, resulting in gastrointestinal absorption. Smaller particles are deposited more deeply in the respiratory tract where absorption through the lungs can occur. Sources of inhaled arsenic for the public include tobacco smoke, burning of CCA-treated wood or arsenic-containing coal, and emissions from nearby smelting operations.

Slide 12: Routes of Exposure: Dermal

Arsenic has poor dermal absorption. Contact with preserved wood products containing arsenic could conceivably result in arsenic exposure, but not enough information is known to make a statement about skin absorption in specific conditions.

Slide 13: Populations at Risk

Next, we will discuss information on populations at risk for exposure to arsenic.

Slide 14

Populations at risk for excess arsenic exposure include people who consume water from arsenic-contaminated wells, live in areas with highly contaminated soils, or burn coal or pressure-treated wood for home heating. Other populations at risk include people who engage in hobbies that could involve the use of arsenic-containing products, such as gardening with arsenic-containing pesticides, and those who work in industries that use arsenic or produce arsenic compounds as byproducts.

Slide 15: Populations at Risk: Occupational Exposure

Workers at risk of arsenic exposure through their occupation include miners, smelters, those who work in agriculture applying arsenic-containing pesticides, wood treatment workers who apply CCA to lumber, and workers in microelectronics or semiconductor industries.

Slide 16: Pediatric Populations

Children are uniquely susceptible to arsenic and other toxic exposures. In general, children breathe more air, drink more water, and eat more food per pound of body weight than adults and are more likely to put their hands in their mouths. A child's developing organs and systems also might not be able to metabolize and excrete harmful contaminants that enter their bodies. Additionally, children have more time to develop health conditions and diseases than people who are exposed later in life. Health problems from an environmental exposure can take years to become evident.

Fetal development is another period of vulnerability to toxic exposures. Exposure to hazardous substances *in utero* can potentially affect the development of fetal organ systems.

Slide 17: Pediatric Populations, cont.

The arsenic exposure pathway varies depending on the child's developmental stage.

Arsenic is known to cross the placenta, and the levels of arsenic in cord blood closely approximate those in maternal blood. There is growing evidence from human and animal studies that exposure to inorganic arsenic during prenatal development could increase the risk of adverse health effects. These adverse effects include impaired development *in utero* and neurodevelopmental toxicity in infants and young children.

Breast milk can contain low levels of arsenic. Exposure can also occur when contaminated water is used to make formula or given to children to drink. However, breast milk continues to be the ideal nutrition for infants, despite the potential presence of environmental contaminants. In nearly every circumstance, CDC and the American Academy of Pediatrics recommend that nursing women continue to breastfeed. Clinicians can help patients decide to breastfeed based on factors specific to the patient and the child.

Infants and children have less varied diet patterns than adults, and elevated levels of inorganic arsenic in foods that infants eat could represent a significant source of exposure. The Food and Drug Administration, or FDA, aims to reduce health effects associated with exposure to inorganic arsenic early in life. Rice cereals are the most consumed infant cereals in the United States. The FDA has determined an action level of 100 micrograms per kilogram or 100 parts per billion for inorganic arsenic in infant rice cereals.

Slide 18: Health Effects

Next, we will cover the health effects of arsenic.

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The development of toxic effects after arsenic exposure depends on the form of arsenic; the frequency, duration, dose, and route of exposure; and the susceptibility of the patient. The susceptibility of a patient for developing disease depends on factors such as nutritional status and genetic differences in individual arsenic methylation capacity.

Slide 20: Clinical Presentation: Acute Exposure

Acute toxicity from arsenic infrequently results from an intentional or accidental ingestion of a large amount of inorganic arsenic. It is difficult to determine the fatal dose in humans because there are only case reports of acute exposure in the literature.

The classic presenting symptoms of acute arsenic toxicity include severe hemorrhagic gastroenteritis with abdominal pain, vomiting, and “bloody rice water” diarrhea. Multisystem organ dysfunction with elevated liver enzymes, renal injury, and disseminated intravascular coagulation can occur, as well as dehydration with hypotension and cardiovascular collapse.

Acute tubular necrosis with acute renal failure has occurred with acute arsenic exposure. Encephalopathy has been reported within 24 to 72 hours following acute exposure, as well as in chronic exposures. Milder clinical features associated with acute exposure include numbness, muscle cramps, facial edema, and gastrointestinal effects such as nausea, vomiting, and diarrhea.

Slide 21: Clinical Presentation: Chronic Exposure

Chronic exposure can occur when an individual is exposed to low levels of arsenic over months to years, usually from contaminated drinking water such as well water. Skin lesions are among the most common and characteristic effects of chronic arsenic exposure in humans. With long-

term exposure to high levels of inorganic arsenic, pigmentation changes and keratosis can occur initially. Hyperpigmentation is characterized as raindrop-like spots of pigmentation, diffuse dark brown spots, or diffuse darkening of the skin on the limbs or trunk. Areas of hyperpigmentation can be interspersed with small areas of hypopigmentation on the face, neck, and back. Keratosis can present as diffuse thickening of the skin or as nodules on the palms or soles. These skin lesions develop after a minimum exposure of approximately five years and can be a precursor to nonmelanoma skin cancer. Peripheral neuropathy can also occur and could be one of the only symptoms of chronic arsenic exposure. This neuropathy occurs in a symmetrical stocking-glove distribution in the hands and feet. It results from damage to the sensory neurons more than the motor neurons.

Slide 22: Clinical Presentation: Chronic Exposure, continued

Other adverse health effects that can be associated with long-term ingestion of inorganic arsenic. They include developmental effects, pulmonary disease, type 2 diabetes mellitus, and cardiovascular disease. Hematological effects can include bone marrow suppression and pancytopenia. Inorganic arsenic can also affect the female and male reproductive systems. Females can have decreased weight of the ovaries and uterus, while males can have reduced weight of the testes and accessory sex organs as well as decreased epididymal sperm counts.

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The EPA, the U.S. Department of Health and Human Service's National Toxicology Program, and the International Agency for Research on Cancer have classified arsenic and arsenic compounds as carcinogenic to humans. Arsenic exposure is associated with lung cancer, nonmelanoma skin cancers, and bladder cancer. There is limited evidence for association with kidney, liver, and prostate cancers.

Slide 24: Clinical Presentation: Chronic Exposure, cont.

Next, we will cover clinical evaluation.

Slide 25: Clinical Evaluation

When evaluating a patient potentially exposed to arsenic, it is important to start with a detailed exposure history. Assess possible current and past environmental exposures and ask about the patient's current and previous occupations. Perform a physical exam that pays close attention to skin and nervous system findings and laboratory evaluation when indicated.

Slide 26: Clinical Evaluation: Exposure History

When taking an exposure history in an evaluation of a patient with suspected arsenic exposure, focused questioning might be able to identify the source of.

When asking about environmental exposure, assess where the patient spends a significant amount of time. Focus on proximity to mining sites, orchards, farms, CCA-treated wooden

playground structures, and hazardous waste sites. It is also important to ask about arsenic-contaminated sources of water for drinking, cooking, and making infant formula, especially private well water sources.

Questions should also assess a patient's hobbies. Ask about current and historical use of arsenic-based pesticides for gardening inside and outside the home. Ask the patient about home heating methods, particularly CCA-treated wood- or coal-burning stoves, fireplaces, and other sources of fuel. When taking a medication history, ask about traditional, imported, homeopathic and naturopathic remedies that can contain arsenic. Questions about occupational history should focus on work in industries that could be at risk for arsenic exposure, such as the manufacturing of microelectronics or semiconductors and pesticide production or application.

Slide 27: Clinical Evaluation: Physical Examination

The physical examination should focus on major organs and systems that arsenic could affect, including checking for evidence of skin lesions and peripheral neuropathy.

Slide 28: Clinical Evaluation: Laboratory

The symptoms of arsenic exposure can be nonspecific or delayed, which can make an early clinical diagnosis difficult.

Urinary arsenic tests can be ordered as total or speciated arsenic. The most helpful laboratory test for recent arsenic exposure is a 24-hour urinary speciated arsenic level, which can distinguish toxic inorganic arsenic from nontoxic organic arsenic. However, total arsenic is often the only 24-hour urine test available. A total urinary arsenic level includes inorganic arsenic and its metabolites that may result in toxicity. However, the total urinary arsenic level also includes nontoxic organic arsenic, such as arsenobetaine and arsenocholine, from seafood consumption within the past 48 hours.

Spot urine specimens for arsenic and creatinine can be helpful in an emergency.

Although tests of nails and hair for arsenic can indicate chronic exposure, they are of limited clinical utility because there are no accepted reference ranges or population means.

In exposed patients, a complete blood count can evaluate for hematological effects, including anemia, leukopenia, and thrombocytopenia. Blood glucose testing can assess for hyperglycemia.

Slide 29: Treatment and Follow-up

Now, treatment and follow-up of patients exposed to arsenic will be covered.

Slide 30: Treatment: Overview

Acute and chronic arsenic poisoning present with a wide spectrum of signs and symptoms. The symptoms are largely dependent on the route of exposure, chemical form, dose, and time elapsed since exposure. Laboratory confirmation of arsenic exposure is often not available in time to guide therapy in the acute setting. Therefore, treatment must often be initiated based on history and clinical findings alone.

Slide 31: Treatment: Acute Exposure

Patients with suspected acute arsenic poisoning generally require aggressive supportive care and management in an intensive care setting. Care and management options include gastrointestinal decontamination and hemodynamic stabilization with fluid and electrolyte replacement.

Chelating agents, such as dimercaprol, can prevent the effects of arsenic toxicity if administered within a few hours of arsenic exposure. However, all chelating agents can have potentially life-threatening side effects. When considering chelation therapy, consult with a medical toxicologist or other specialist with expertise and experience in managing acute toxicity. Poison control centers have medical toxicologists available for consultation.

Slide 32: Treatment: Chronic Exposure

In cases of chronic arsenic exposure, the primary goal is to end the exposure by first identifying and then mitigating or preventing further exposure to arsenic. Removal of the toxic arsenic source might not always be possible or feasible. Symptoms generally improve following cessation of exposure but can persist with an extended recovery period. Treatment depends on several factors, including urinary arsenic levels, duration of exposure, severity of neurological damage, and current symptoms. Manage symptomatic patients with supportive care.

Slide 33: Patient Follow-Up

Periodic clinical evaluations of patients exposed to arsenic can detect abnormalities at an early stage. Further testing can be based on symptoms, physical exam findings, and standard clinical practice. Refer to screening recommendations for cancer and other chronic diseases from the U.S. Preventive Services Task Force. Consider consulting with a specialist in medical toxicology or occupational and environmental medicine to develop a plan for periodic monitoring if needed. The Pediatric Environmental Health Specialty Units, or PEHSUs, are a national network of experts in the prevention, diagnosis, management, and treatment of health issues that arise from environmental exposures from preconception through adolescence. PEHSUs can provide evidence-based information about arsenic exposure that affects children and families.

Slide 34: Patient Counseling and Exposure Reduction

Finally, we will discuss patient counseling and exposure reduction.

Slide 35:

Avoid exposure to toxic arsenic whenever possible. Because the main route of exposure is ingestion, encourage patients to know the arsenic level in their drinking water, particularly if they use a private well. Arsenic levels should be below the EPA drinking water standard of 10 micrograms per liter.

Counsel patients who use well water to have their water tested for arsenic through a local health department to ensure arsenic concentrations are below the EPA drinking water standard.

Remove arsenic in drinking water with certified filters. If removal methods are not feasible, use an alternative source of water for drinking, cooking, and other activities that could result in ingestion of water.

Arsenic in household water does not volatilize nor does it readily absorb through the skin while bathing. Therefore, showering and bathing in household water with arsenic is not a concern.

Advise patients to use a safe water supply for gardening and crop irrigation.

Encourage patients to eat a wide range of foods, including a variety of first foods for infants.

Counsel patients who work with arsenic to properly use personal protective equipment. Furthermore, advise patients who work with arsenic to remove their shoes and clothes before entering their homes to avoid exposing family members to arsenic.

Slide 36

To conclude, here are some important takeaways about arsenic.

Slide 37: Important Takeaways

Patients with acute ingestion of arsenic can present with gastrointestinal symptoms like severe diarrhea that can progress to multisystem organ dysfunction and death. Initial symptoms of chronic exposure to high levels of arsenic include skin lesions and hyperpigmentation. Cancers associated with arsenic exposure include lung cancer, nonmelanoma skin cancers, and bladder cancers. A 24-hour urinary speciated arsenic level is the most useful laboratory test for recent arsenic exposure. Finally, counseling measures can include patient education on ways to identify and mitigate environmental and occupational sources of chronic arsenic exposure.

Slide 38: Questions?

For more information or questions, please contact the Environmental Medicine and Health Systems Intervention Section at c-e-a-t-s-d-r at c-d-c dot gov or C-D-C at one-eight hundred -C-D-C-INFO (Teletypewriter: one eight eight eight two three two six three four eight) or w-w-w dot c-d-c dot gov.