ARSENIC POISONING

1. The Disease Definition

Arsenic is a naturally occurring element widely distributed in the earth's crust. In the environment, arsenic is combined with oxygen, chlorine, and sulfur to form inorganic arsenic compounds. Arsenic in animals and plants combines with carbon and hydrogen to form organic arsenic compounds. Inorganic arsenic compounds are mainly used to preserve wood. Organic arsenic compounds are used as pesticides, primarily on cotton plants.

A. Clinical Description

Breathing high levels of inorganic arsenic can cause a sore throat or irritated lungs. Ingesting high levels of inorganic arsenic can result in death. Low levels of arsenic ingestion can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. Ingesting or breathing low levels of inorganic arsenic for a long time can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso. Skin contact with inorganic arsenic may cause redness and swelling.

Organic arsenic compounds are less toxic than inorganic arsenic compounds. Exposure to high levels of some organic arsenic compounds may cause effects similar to those of inorganic arsenic. Several studies have shown that inorganic arsenic can increase the risk of cancers of the lung, skin, bladder, liver, kidney, and prostate. The World Health Organization (WHO), the U.S. Department of Health and Human Services (DHHS), and the U.S. Environmental Protection Agency (EPA) have determined that inorganic arsenic is a human carcinogen.

Chronic exposure to arsenic can lead to whitish lines (Mees lines) on the fingernails, dermatitis, mild pigmentation keratosis of the skin, vasospasticity, gross pigmentation with hyperkeratinization of exposed areas, wart formation, decreased nerve conduction velocity, and lung cancer. Acute exposures can cause lung distress and death. The breath and tissue fluids of patients exposed to arsenic frequently smell like garlic.

B. Sources of Exposure

Arsenic exposure can occur through inhalation, ingestion, or dermal or eye contact. Historically, arsenic was used to treat syphilis and other diseases. The use of arsenic as a pesticide began in the late nineteenth century. Though the majority of arsenic-based pesticides are no longer used in agriculture or horticulture in the U.S., arsenic-based wood preservatives are still used in nonresidential construction. (EPA banned residential uses of arsenic-based wood preservatives in 2004). Today arsenic poisoning occurs through workplace exposure, from contaminated wine, moonshine or other products, or because of malicious intent. In some areas, arsenic can leach from bedrock to contaminate ground water and wells. There have been sporadic incidents of heavy metal contamination of unregulated herbal preparations and nutritional supplements. People who utilize complementary and alternative medicine (CAM) may have an increased risk of exposure to a variety of toxic substances including arsenic, especially when using products that are manufactured outside of the USA.

C. Population at Risk

Workers in industries that use inorganic arsenic and its compounds, including wood preservation, glass production, the production of nonferrous metal alloys, and electronic semiconductor manufacturing, that use inorganic arsenic and its compounds are at the highest risk for exposure to arsenic. Inorganic arsenic is also found in coke oven emissions associated with the smelter industry (arsenic is a byproduct of smelting lead, gold, zinc, cobalt, and nickel ores). Occupational exposure to arsenic hazards are addressed in specific

OSHA (Occupational Safety and Health Administration) standards for general industry, shipyard employment, and the construction industry. More information is available at www.osha.gov/SLTC/arsenic/.

The general population may be exposed if they live in areas where arsenic contaminates ground water or wells. Wooden decks and play areas constructed out of wood treated with arsenic-based wood preservatives prior to 2004 have been shown to increase the risk of exposure through contamination of the surrounding soil, direct contact, or during renovation or repair. Soil contamination may also be a risk in areas where arsenic-containing pesticides or industrial products were formerly utilized.

According to the American Association of Poison Control Centers' (AAPCC) National Poison Data System (NPDS), 794 non–pesticide-related arsenic exposures with 3 fatalities, and 20 arsenic-containing pesticide exposures with no fatalities, were reported in the United States during 2016.

D. Diagnosis, Treatment, and Prognosis

Absorbed arsenic is rapidly distributed into tissue storage sites with a blood half-life of <6 hours. There are tests to measure the level of arsenic in blood, urine, hair, or fingernails. These tests can determine exposure to above-average levels of arsenic. Test results alone cannot predict how the arsenic levels will affect health.

Normally, humans consume 5 to 25 micrograms (mcg) of arsenic each day as part of their normal diet; therefore, normal urine arsenic output is <25 mcg/L for a 24 hour urine sample. After a seafood meal (seafood contains a nontoxic, organic form of arsenic), the urine output of arsenic may increase to 300 mcg/L (micrograms per liter) for 1 day, after which it will decline to <25 mcg/L.

Arsenic testing using a urine test is the most reliable for acute and chronic arsenic exposure. Testing can be done on random (spot) urine samples or by utilizing a twenty-four hour collection technique. Testing protocols, reporting units, and reference values vary, so refer to your reference laboratory.

Acute exposure: Due to the short half-life of arsenic in the blood, urine is the preferred specimen for detection of exposure. Elevated urine results should be fractionated to differentiate between toxic inorganic forms and relatively nontoxic organic forms. When investigating very recent exposure (<24 hours) blood testing may be helpful. In patients with acute arsenic poisoning, blood arsenic concentrations commonly range from several hundred to several thousand µg/L. Blood arsenic levels may be reported as micrograms per liter (µg/L) or nanograms per milliliter (ng/ml), which are equivalent to each other. Unless a blood specimen is drawn within 2 days of exposure, arsenic is not likely to be detected in a blood specimen, so blood arsenic testing is not useful for evaluation of chronic arsenic exposure.

Chronic exposure or screening: The Biological Exposure Index (BEI) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for the sum of inorganic arsenic and methylated metabolites of arsenic is 35 µg/L (micrograms per liter). Clinical symptoms may not be evident at 35 µg/L; toxic thresholds are not well established. For specimens with a total concentration between 35-2,000 µg/L, fractionation is recommended to determine proportion of organic, inorganic, and methylated forms. If low-level chronic poisoning is suspected, the µg/gCRT ratio (micrograms per gram of creatinine) may be more sensitive than total arsenic concentration. In some situations, it may be appropriate to fractionate specimens with a ratio >30 µg/gCRT despite a total arsenic concentration <35 µg/L.

Chronic or past exposures (>3 weeks): Analysis of hair or nails is most useful in determining time of exposure. Tests on hair and fingernails can measure exposure to high levels of arsenic over the previous 6 to 12 months.

Pre-hospital care consists of providing support to the airway, breathing, and circulation. Hemodynamic stabilization is of primary importance in emergency-room treatment, and large amounts of crystalloid

solutions may be required because of vomiting and diarrhea. Treatment of acute arsenic toxicity is supportive. Chelation therapy is imperative in all patients who are symptomatic. Once arsenic is distributed into the tissues, treatment may be unsuccessful. Clinical trials are not available, but it makes some sense to attempt to remove arsenic from the plasma before it reaches the tissues. Because the clearance of arsenic by dialysis is substantial, hemodialysis may be indicated if available within a short time after exposure.

Perform a careful neurological evaluation in follow-up of all patients because the peripheral neuropathy, which may develop after an acute exposure, may not appear for 2-3 weeks. A complete work and travel history and environmental assessment are helpful

Worker medical monitoring information can be found on the OSHA website at www.osha.gov/SLTC/arsenic/.

E. Prevention of Exposure

Controlling occupational arsenic exposure is best accomplished through substituting it with a non-toxic chemical, depending on the application. If this cannot be done, engineering, administrative, and personal protective equipment (PPE) including protective clothing should be used.

Individuals living in areas known to have groundwater arsenic exposure should check with their local public health department for more information regarding well water testing.

Consumers of complementary and alternative medicine supplements, especially those manufactured outside of the USA should discuss their risk of exposure to heavy metals and other toxins with their medical practitioners to determine the need for testing or intervention. An FDA fact sheet is available at https://www.fda.gov/forconsumers/consumerupdates/ucm050798.htm

2. Reporting Criteria

A. Disease Reporting

Arsenic poisoning is currently reportable if:

- Blood arsenic values are equal to or greater than the equivalent of 70 micrograms per liter (µg/L or mcg/L).
- Urine arsenic values for spot or random urine samples are equal to or greater than the equivalent of 100 micrograms per gram of creatinine (mcg/gCrt)

Arsenic poisonings must be reported within a week to the Iowa Department of Public Health by the physician or health practitioner attending any person having a reportable disease and by laboratories performing tests identifying reportable diseases. Reporting can be through the Iowa Disease Surveillance System (IDSS), or by phone, fax, or mail. The preferred reporting method is through IDSS. To report via phone, fax or mail, please use the contact information and Arsenic Case Report Form available in the Epi Manual and online at https://wiki.idph.iowa.gov/Portals/3/userfiles/12/Arsenic_Case_Report_Form.pdf