MAYO CLINIC LABORATORIES

Test Definition: HMDB

Heavy Metals Screen with Demographics, Blood

Overview

Useful For

Detecting exposure to arsenic, lead, cadmium, and mercury

Profile Information

Test Id	Reporting Name	Available Separately	Always Performed
ASB	Arsenic, B	Yes	Yes
PBHMB	Lead, B	Yes, (Order PBDV)	Yes
CDB	Cadmium, B	Yes	Yes
HG	Mercury, B	Yes	Yes
DEMO6	Patient Demographics	No	Yes

Testing Algorithm

For more information see Porphyria (Acute) Testing Algorithm

Special Instructions

- Lead and Heavy Metals Reporting
- Porphyria (Acute) Testing Algorithm
- Metals Analysis Specimen Collection and Transport
- Lead and Heavy Metals Reporting-Spanish

Method Name

Triple Quadrupole Inductively Coupled Plasma Mass Spectrometry (ICP-MS/MS)

NY State Available

Yes

Specimen

Specimen Type

Whole blood

Necessary Information

If not ordering electronically, the Lead and Heavy Metals Reporting **(T491) is required**. Send with specimen.

Specimen Required

Patient Preparation: High concentrations of gadolinium and iodine are known to potentially interfere with most inductively coupled plasma mass spectrometry-based metal tests. If either gadolinium- or iodine-containing contrast

media has been administered, **a specimen should not be collected for 96 hours**.

Supplies:

-Metal Free EDTA 3 mL Tube (T989)

-Metal Free B-D Tube (EDTA), 6 mL (T183)

Container/Tube:

Preferred: Royal blue-top BD vacutainer with EDTA blood collection tube (3 mL) (BD catalog no. 367777) (T989)

Acceptable: Royal blue-top BD Vacutainer Plus with EDTA blood collection tube (6 mL) (BD catalog no. 368381) (T183)

Specimen Volume: 1 mL

Collection Instructions:

1. See Metals Analysis Specimen Collection and Transport for complete instructions.
2. Send whole blood specimen in original collection tube. **Do not aliquot**.

Forms

Lead and Heavy Metals Reporting (T491) or Lead and Heavy Metals Reporting-Spanish (T956)

Specimen Minimum Volume

0.25 mL

Reject Due To

Gross hemolysis	OK
Gross lipemia	OK
Gross icterus	OK

Specimen Stability Information

Specimen Type	Temperature	Time	Special Container
Whole blood	Refrigerated (preferred)	28 days	
	Ambient	28 days	
	Frozen	28 days	

Clinical & Interpretive

Clinical Information

Arsenic:

Arsenic (As) exists in many toxic and nontoxic forms. The toxic forms are the inorganic species As(5+), also denoted as As(V), the more toxic As(3+), also known as As(III), and their partially detoxified metabolites, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA). Detoxification occurs in the liver as As(3+) is oxidized to As(5+) and then methylated to MMA and DMA. As a result of these detoxification steps, As(3+) and As(5+) are found in the urine shortly after ingestion, whereas MMA and DMA are the species that predominate more than 24 hours after ingestion.

Blood concentrations of arsenic are elevated for a short time after exposure, after which arsenic rapidly disappears into

tissues because if its affinity for tissue proteins. The body treats arsenic like phosphate, incorporating it wherever phosphate would be incorporated. Arsenic "disappears" into the normal body pool of phosphate and is excreted at the same rate as phosphate (excretion half-life of 12 days). The half-life of inorganic arsenic in blood is 4 to 6 hours, and the half-life of the methylated metabolites is 20 to 30 hours. Abnormal blood arsenic concentrations (>12 ng/mL) indicate significant exposure but will only be detected immediately after exposure. Arsenic is not likely to be detected in blood specimens drawn more than 2 days after exposure because it has become integrated into nonvascular tissues. Consequently, blood is not a good specimen to screen for arsenic, although periodic blood levels can be determined to follow the effectiveness of therapy. Urine is the preferred specimen for assessment of arsenic exposure.

A wide range of signs and symptoms may be seen in acute arsenic poisoning, including headache, nausea, vomiting, diarrhea, abdominal pain, hypotension, fever, hemolysis, seizures, and mental status changes. Symptoms of chronic poisoning, also called arseniasis, are mostly insidious and nonspecific. The gastrointestinal tract, skin, and central nervous system are usually involved. Nausea, epigastric pain, colic (abdominal pain), diarrhea, and paresthesias of the hands and feet can occur.

Lead:
Lead is a heavy metal commonly found in the environment that can be an acute and chronic toxin.

Lead was banned from household paints in 1978 but is still found in paint produced for nondomestic use and in artistic pigments. Ceramic products available from noncommercial suppliers (such as local artists) often contain significant amounts of lead that can be leached from the ceramic by weak acids, such as vinegar and fruit juices. Lead is found in dirt from areas adjacent to homes painted with lead-based paints and highways where lead accumulates from use of leaded gasoline. Use of leaded gasoline has diminished significantly since the introduction of nonleaded gasolines, which have been required in personal automobiles since 1972. Lead is found in soil near abandoned industrial sites where lead may have been used. Water transported through lead or lead-soldered pipe will contain some lead with higher concentrations found in water that is weakly acidic. Some foods (for example: moonshine distilled in lead pipes) and some traditional home medicines contain lead.

The typical diet in the United States contributes 1 to 3 mcg of lead per day, of which 1% to 10% is absorbed; children may absorb as much as 50% of the dietary intake, and the fraction of lead absorbed is enhanced by nutritional deficiency. The majority of the daily intake is excreted in the stool after direct passage through the gastrointestinal tract. While a significant fraction of the absorbed lead is rapidly incorporated into bone and erythrocytes, lead ultimately distributes among all tissues, with lipid-dense tissues, such as the central nervous system, being particularly sensitive to organic forms of lead. All absorbed lead is ultimately excreted in the bile or urine. Soft-tissue turnover of lead occurs within approximately 120 days.

Lead expresses its toxicity by several mechanisms. It avidly inhibits aminolevulinic acid dehydratase and ferrochelatase, 2 of the enzymes that catalyze synthesis of heme; the end result is decreased hemoglobin synthesis resulting in anemia. Lead also is an electrophile that avidly forms covalent bonds with the sulfhydryl group of cysteine in proteins. Thus, proteins in all tissues exposed to lead will have lead bound to them. The most common sites affected are epithelial cells of the gastrointestinal tract and of the kidney.

Avoidance of exposure to lead is the treatment of choice. However, chelation therapy is available to treat severe disease. Oral dimercaprol may be used in the outpatient setting except in the most severe cases.

Cadmium:
The toxicity of cadmium resembles the other heavy metals (arsenic, mercury, and lead) in that it attacks the kidney; kidney dysfunction with proteinuria with slow onset (over a period of years) is the typical presentation.

Breathing the fumes of cadmium vapors leads to nasal epithelial deterioration and pulmonary congestion resembling chronic emphysema.

The most common source of chronic exposure comes from spray painting of organic-based paints without use of a protective breathing apparatus; auto repair mechanics represent a susceptible group for cadmium toxicity. In addition, another common source of cadmium exposure is tobacco smoke.

Mercury:
Mercury (Hg) is relatively nontoxic in its elemental form. If Hg(0) is chemically modified to the ionized, inorganic species, Hg(2+), it becomes toxic. Further bioconversion to an alkyl Hg, such as methyl Hg (CH3Hg[+]), yields a species of mercury that is highly selective for lipid-rich tissue such as neurons and is very toxic. The relative order of toxicity is:

Least Toxic -- Hg(0) < Hg(2+) << [CH3Hg](+) -- Very Toxic

Mercury can be chemically converted from the elemental state to the ionized state. In industry, this is frequently done by exposing Hg(0) to strong oxidizing agents, such as chlorine.

Hg(0) can be bioconverted to both Hg(2+) and alkyl Hg by microorganisms that exist in the normal human gut as well as in the bottom sediment of lakes, rivers, and oceans. When Hg(0) enters bottom sediment, it is absorbed by bacteria, fungi, and small microorganisms; they metabolically convert it to Hg(2+), CH3Hg(+), and C2H6Hg. Should these microorganisms be consumed by larger marine animals and fish, the mercury passes up the food chain in the rather toxic form.

Mercury expresses its toxicity in 3 ways:
-Hg(2+) is readily absorbed and reacts with sulfhydryl groups of protein, causing a change in the tertiary structure of the protein-a stereoisomeric change-with subsequent loss of the unique activity associated with that protein. Because Hg(2+) becomes concentrated in the kidney during the regular clearance processes, this target organ experiences the greatest toxicity.
-With the tertiary change noted previously, some proteins become immunogenic, eliciting a proliferation of T lymphocytes that generate immunoglobulins to bind the new antigen; collagen tissues are particularly sensitive to this.
-Alkyl Hg species, such as CH3Hg(+), are lipophilic and avidly bind to lipid-rich tissues, such as neurons. Myelin is particularly susceptible to disruption by this mechanism.

Members of the public will occasionally become concerned about exposure to mercury from dental amalgams. Restorative dentistry has used a mercury-silver amalgam for approximately 90 years as a filling material. A small amount of mercury (2-20 mcg/day) is released from a dental amalgam when it was mechanically manipulated, such as by chewing. The habit of gum chewing can cause release of mercury from dental amalgams greatly above normal. The normal bacterial microbiota present in the mouth converts a fraction of this to Hg(2+) and CH3Hg(+), which was shown to be incorporated into body tissues. The World Health Organization safety standard for daily exposure to mercury is 45

mcg/day. Thus, if one had no other source of exposure, the amount of mercury released from dental amalgams is not significant.(1) Many foods contain mercury. For example, commercial fish considered safe for consumption contain less than 0.3 mcg/g of mercury, but some game fish contain more than 2.0 mcg/g and, if consumed on a regular basis, contribute to significant body burdens.

Therapy is usually monitored by following urine output; therapy may be terminated after urine excretion is below 50 mcg/day.

Reference Values

ARSENIC
<13 ng/mL
Reference values apply to all ages.

LEAD
<3.5 mcg/dL
Critical values
Pediatrics (< or =15 years): > or =20.0 mcg/dL
Adults (> or =16 years): > or =70.0 mcg/dL

CADMIUM
<5.0 ng/mL
Reference values apply to all ages.

MERCURY
<10 ng/mL
Reference values apply to all ages.

Interpretation

Arsenic:
Abnormal blood arsenic concentrations (>12 ng/mL) indicate significant exposure.

Absorbed arsenic is rapidly distributed into tissue storage sites with a blood half-life of less than 6 hours. Unless a blood specimen is drawn within 2 days of exposure, arsenic is not likely to be detected in a blood specimen.

Lead:
For pediatric patients, there may be an association with blood lead values of 5.0 to 9.9 mcg/dL and adverse health effects. The current reference level at which the Centers of Disease Control and Prevention recommends public health actions be initiated is 3.5 mcg/dL in patients 0 to 5 years old and 5 mcg/dL for patients 6 years and older. The most recent National Health and Nutrition Examination Survey (NHANES) data shows that 97.5 percentile for blood lead levels in US adults age 16 years and older is 3.46 mcg/dL. In concurrence with the reference value concept that there is no safe level of lead in blood, the Council of State and Territorial Epidemiologists Occupational Health Subcommittee approved lowering the blood lead threshold from 5 to 3.5 mcg/dL for adults. Follow-up testing after 3 to 6 months may be warranted.

Chelation therapy is indicated when whole blood lead concentration is greater than 25.0 mcg/dL in children or greater than 45.0 mcg/dL in adults.

The Occupational Safety and Health Administration has published the following standards for employees working in industry:
-Employees with a single whole blood lead result greater than 60.0 mcg/dL must be removed from workplace exposure.
-Employees with whole blood lead levels greater than 50.0 mcg/dL averaged over 3 blood samplings must be removed from workplace exposure.
-An employee may not return to work in a lead exposure environment until their whole blood lead level is less than 40 mcg/dL.

New York State has mandated inclusion of the following statement in reports for children under the age of 6 years with blood lead in the range of 5.0 to 9.9 mcg/dL: "Blood lead levels in the range of 5.0-9.9 mcg/dL have been associated with adverse health effects in children aged 6 years and younger."

Cadmium:
Normal blood cadmium concentration is less than 5.0 ng/mL, with most results in the range of 0.5 to 2.0 ng/mL.

Acute toxicity will be observed when the blood level exceeds 50 ng/mL.

Mercury:
The quantity of mercury (Hg) found in blood and urine correlates with degree of toxicity. Hair analysis can be used to document the time of peak exposure if the event was in the past.

Normal whole blood mercury concentration is usually less than 10 ng/mL.

Individuals who have mild exposure during work, such as dentists, may routinely have whole blood mercury levels up to 15 ng/mL.

Significant exposure is indicated when the whole blood mercury concentration is greater than 50 ng/mL if exposure is due to alkyl Hg, or greater than 200 ng/mL if exposure is due to Hg(2+).

Cautions

No significant cautionary statements

Clinical Reference

1. Lee R, Middleton D, Calwell K, et al. A review of events that expose children to elemental mercury in the United States. Environ Health Perspect. 2009;117(6):871-878
2. Hall M, Chen Y, Ahsan H, et al. Blood arsenic as a biomarker of arsenic exposure: results from a prospective study. Toxicology. 2006;225(2-3):225-233
3. Centers for Disease Control and Prevention (CDC). National Report on Human Exposure to Environmental Chemicals. CDC; Updated September 29, 2023. Accessed December 3, 2024. Available at www.cdc.gov/exposurereport
4. de Burbure C, Buchet J-P, Leroyer A, et al. Renal and neurologic effects of cadmium, lead, mercury, and arsenic in children: evidence of early effects and multiple interactions at environmental exposure levels. Environ Health Perspect.

2006;114(4):584-590
5. Kosnett MJ, Wedeen RP, Rothenberg SJ, et al. Recommendations for medical management of adult lead exposure. Environ Health Perspect. 2007;115(3):463-471
6. Jusko T, Henderson C, Lanphear B, Cory-Slechta DA, Parsons PJ, Canfield RL. Blood lead concentrations <10 mcg/dL and child intelligence at 6 years of age. Environ Health Perspect. 2008;116(2):243-248
7. Moreau T, Lellouch J, Juguet B, Claude JR, Juguet B, Festy B. Blood cadmium levels in a general population with special reference to smoking. Arch Environ Health. 1983;38(3):163-167
8. Bjorkman L, Lundekvam B, Laegreid T, et al. Mercury in human brain, blood, muscle and toenails in relation to exposure: an autopsy study. Environ Health. 2007;6:30
9. deBurbure C, Buchet JP, Leroyer A, et al. Renal and neurologic effects of cadmium, lead, mercury, and arsenic in children: evidence of early effects and multiple interactions at environmental exposure levels. Environ Health Perspect. 2006;114(4):584-590
10. Strathmann FG, Blum LM: Toxic elements. In: Rifai N, Chiu RWK, Young I, Burnham CD, Wittwer CT, eds. Tietz Textbook of Laboratory Medicine. 7th ed. Elsevier; 2023:chap 44
11. CSTE Occupational Subcommittee. Management Guidelines for Blood Lead Levels in Adults. 2021. Accessed December 3, 2024. Available at: https://cdn.ymaws.com/www.cste.org/resource/resmgr/occupationalhealth/publications/ManagementGuidelinesforAdult.pdf

Performance

Method Description
The metals of interest are analyzed by triple quadrupole inductively coupled plasma mass spectrometry.(Unpublished Mayo method)

PDF Report
No

Day(s) Performed
Monday through Saturday

Report Available
1 to 3 days

Specimen Retention Time
14 days

Performing Laboratory Location
Mayo Clinic Laboratories - Rochester Superior Drive

Fees & Codes

Fees

- Authorized users can sign in to Test Prices for detailed fee information.
- Clients without access to Test Prices can contact Customer Service 24 hours a day, seven days a week.
- Prospective clients should contact their account representative. For assistance, contact Customer Service.

Test Classification

This test was developed and its performance characteristics determined by Mayo Clinic in a manner consistent with CLIA requirements. It has not been cleared or approved by the US Food and Drug Administration.

CPT Code Information

82175
82300
83655
83825

LOINC® Information

Test ID	Test Order Name	Order LOINC® Value
HMDB	Heavy Metals Scrn with Demographics	29588-1

Result ID	Test Result Name	Result LOINC® Value
32190	Arsenic, B	5583-0
8682	Cadmium, B	5609-3
8618	Mercury, B	5685-3
2588	Lead, B	77307-7
VECP6	Venous/Capillary	31208-2
PTAD6	Patient Street Address	56799-0
PTCI6	Patient City	68997-6
PTST6	Patient State	46499-0
PTZI6	Patient Zip Code	45401-7
PTCN6	Patient County	87721-7
PTPH6	Patient Home Phone	42077-8
PTRA6	Patient Race	32624-9
PTET6	Patient Ethnicity	69490-1
PTOC6	Patient Occupation	11341-5
PTEM6	Patient Employer	80427-8
GDFN6	Guardian First Name	79183-0
GDLN6	Guardian Last Name	79184-8
MDOR6	Health Care Provider Name	52526-1
MDAD6	Health Care Provider Street Address	74221-3
MDCI6	Health Care Provider City	52531-1
MDST6	Health Care Provider State	52532-9
MDZI6	Health Care Provider Zip Code	87720-9

MDPH6	Health Care Provider Phone	68340-9
LABP6	Submitting Laboratory Phone	65651-2