

## Overview

### Useful For

Preferred monitoring for aluminum toxicity in patients undergoing dialysis  
Preferred test for routine aluminum screening  
Monitoring metallic prosthetic implant wear

### Special Instructions

- [Trace Metals Analysis Specimen Collection and Transport](#)

### Method Name

Dynamic Reaction Cell-Inductively Coupled Plasma-Mass Spectrometry (DRC-ICP-MS)

### NY State Available

Yes

## Specimen

### Specimen Type

Serum

### Specimen Required

**Patient Preparation:** High concentrations of gadolinium and iodine are known to interfere with most metal tests. If either gadolinium- or iodine-containing contrast media has been administered, a specimen should not be collected for 96 hours.

### Supplies:

-Greiner Z Trace Element no-additive (Aluminum Only), 6 mL (T713)

-Metal Free Specimen Vial (T173)

**Container/Tube:** Greiner Z Trace Element

**Submission Container/Tube:** 7-mL Mayo metal-free, screw-capped, polypropylene vial

**Specimen Volume:** 1.2 mL

**Collection Instructions:** See [Trace Metals Analysis Specimen Collection and Transport](#) in Special Instructions for complete instructions.

### Forms

If not ordering electronically, complete, print, and send a [Renal Diagnostics Test Request](#) (T830) with the specimen.

### Reject Due To

Gross hemolysis OK

Gross lipemia OK

Gross icterus OK

### Specimen Minimum Volume

0.3 mL

**Specimen Stability Information**

Specimen Type	Temperature	Time	Special Container
Serum	Refrigerated (preferred)	7 days	METAL FREE
	Ambient	7 days	METAL FREE
	Frozen	7 days	METAL FREE

**Clinical & Interpretive**
**Clinical Information**

Under normal physiologic conditions, the usual daily dietary intake of aluminum (5-10 mg) is completely eliminated. Excretion is accomplished by avid filtration of aluminum from the blood by the glomeruli of the kidney. Patients in kidney failure lose the ability to clear aluminum and are candidates for aluminum toxicity. Many factors increase the incidence of aluminum toxicity in patients with kidney failure:

- Aluminum-laden dialysis water can expose dialysis patients to aluminum.
- Aluminum-laden albumin can expose patients to an aluminum burden they cannot eliminate.
- The dialysis process is not highly effective at eliminating aluminum.
- Aluminum-based phosphate binder gels are administered orally to minimize phosphate accumulation; a small fraction of this aluminum may be absorbed and accumulated.

If it is not removed by kidney filtration, aluminum accumulates in the blood where it binds to proteins such as albumin and is rapidly distributed through the body. Aluminum overload leads to accumulation of aluminum at 2 sites: brain and bone. Brain deposition has been implicated as a cause of dialysis dementia. In bone, aluminum replaces calcium at the mineralization front, disrupting normal osteoid formation.

Deposition of aluminum in bone also interrupts normal calcium exchange. The calcium in bone becomes unavailable for resorption back into blood under the physiologic control of parathyroid hormone (PTH) and results in secondary hyperparathyroidism. While PTH is typically quite elevated in kidney failure, 2 different processes may occur:

- 1) High-turnover bone disease associated with high PTH (>150 pg/mL) and relatively low aluminum (<20 ng/mL)
- 2) Low-turnover bone disease with lower PTH (<50 pg/mL) and high aluminum (>60 ng/mL). Low-turnover bone disease indicates aluminum intoxication.

Serum aluminum concentrations are likely to be increased above the reference range in patients with metallic joint prosthesis. Prosthetic devices produced by Zimmer Company and Johnson and Johnson typically are made of aluminum, vanadium, and titanium. Prosthetic devices produced by Depuy Company, Dow Corning, Howmedica, LCS, PCA, Osteonics, Richards Company, Tricon, and Whiteside, typically are made of chromium, cobalt, and molybdenum. This list of products is incomplete, and these products change occasionally; see prosthesis product information for each device for composition details.

**Reference Values**

<7 ng/mL

<60 ng/mL (dialysis patients)

For SI unit Reference Values, see <https://www.mayocliniclabs.com/order-tests/si-unit-conversion.html>

**Interpretation**

Patients in kidney failure not receiving dialysis therapy invariably have serum aluminum levels above the 60 ng/mL range.

McCarthy(1) and Hernandez(2) describe a biochemical profile that is characteristic of aluminum overload disease in

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dialysis patients:

-Patients in kidney failure with no signs or symptoms of osteomalacia or encephalopathy usually had serum aluminum below 20 ng/mL and parathyroid hormone (PTH) concentrations above 150 pg/mL, which is typical of secondary hyperparathyroidism.

-Patients with signs and symptoms of osteomalacia or encephalopathy had serum aluminum above 60 ng/mL and PTH concentrations below 50 pg/mL (PTH above the reference range, but low for secondary hyperparathyroidism).

-Patients who had serum aluminum above 60 ng/mL and below 100 ng/mL were identified as candidates for later onset of aluminum-overload disease that required aggressive efforts to reduce their daily aluminum exposure. This was done by switching them from aluminum-containing phosphate binders to calcium-containing phosphate binders, by ensuring that their dialysis water had less than 10 ng/mL of aluminum, and ensuring the albumin used during postdialysis therapy was aluminum free.

Prosthesis wear is known to result in increased circulating concentration of metal ions.<sup>(3)</sup> Modest increase (6-10 ng/mL) in serum aluminum concentration is likely to be associated with a prosthetic device in good condition. Serum concentrations above 10 ng/mL in a patient with an aluminum-based implant not undergoing dialysis suggest significant prosthesis wear. Increased serum trace element concentrations in the absence of corroborating clinical information do not independently predict prosthesis wear or failure.

### Cautions

Failure to pay attention to proper specimen collection procedures can cause abnormal results due to specimen contamination, which can lead to misinterpretation and misdiagnosis:

-Special evacuated blood collection tubes are required for aluminum testing.<sup>(4)</sup> These tubes are readily available (Greiner Z Trace Element no-additive (Aluminum Only), 6 mL T713) and should always be used.

-Most of the common evacuated blood collection devices have rubber stoppers that are comprised of aluminum-silicate. Simple puncture of the rubber stopper for blood collection is sufficient to contaminate the specimen with aluminum. Typically, blood drawn in standard evacuated blood tubes will be contaminated by 20 to 60 ng/mL aluminum.

-The use of wooden applicator sticks or pipette tips during specimen aliquoting can cause abnormal results due to contamination.

### Clinical Reference

1. McCarthy JT, Milliner DS, Kurtz SB, et al: Interpretation of serum aluminum values in dialysis patients. *Am J Clin Pathol.* 1986;86:629-636
2. Hernandez JD, Wesseling K, Salusky IB: Role of parathyroid hormone and therapy with active vitamin D sterols in renal osteodystrophy. *Semin Dial.* 2005;18:290-295
3. Liu TK, Liu SH, Chang CH, Yang RS: Concentration of metal elements in the blood and urine in the patients with cementless total knee arthroplasty. *Tohoku J Exp Med.* 1998;185:253-262
4. Schwarz C, Sulzbacher R, Oberbauer R: Diagnosis of renal osteodystrophy. *Eur J Clin Invest.* 2006;36:13-22
5. Sharma AK, Toussaint ND, Pickering J, et al: Assessing the utility of testing aluminum levels in dialysis patients. *Hemodial Int.* 2015 Apr;19(2):256-262 doi: 10.1111/hdi.12231
6. Riihimaki V, Aitio A: Occupational exposure to aluminum and its biomonitoring in perspective. *Crit Rev Toxicol.* 2012 Nov;42(10):827-853 doi:10.3109/10408444.2012.725027
7. Strathmann FG, Blum LM: Toxic elements In: Rifai N, Horwath AR, Wittwer CT, eds. *Tietz Textbook of Clinical Chemistry and Molecular Diagnostics.* 6th ed. Elsevier; 2018:888-924
8. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. Toxicological Profile for Aluminum. HHS; 2006. Accessed July 20, 2021. Available at [www.atsdr.cdc.gov/toxprofiles/tp22.pdf](http://www.atsdr.cdc.gov/toxprofiles/tp22.pdf)
9. Willhite CC, Karyakina NA, Yokel RA, et al: Systematic review of potential health risks posed by pharmaceutical, occupational and consumer exposures to metallic and nanoscale aluminum, aluminum oxides, aluminum hydroxide, and

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its soluble salts. Crit Rev Toxicol. 2014;44 Suppl 4(Suppl 4):1-80. doi: 10.3109/10408444.2014.934439

## Performance

### Method Description

Aluminum in serum is analyzed by inductively coupled plasma-mass spectrometry in dynamic reaction cell mode using lithium, gallium, and rhodium as internal standards, and a salt matrix calibration.(Unpublished Mayo method)

### PDF Report

No

### Specimen Retention Time

14 days

### Performing Laboratory Location

Rochester

## Fees & Codes

### Test Classification

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

### CPT Code Information

82108