POCT was performed in the ambulance or jet during actual transport. Although this "before transport" portion of testing may impact overall transport costs by altering transport time, it remains a topic for future utilization review.

One concern with POCT in critical care transport is the potential for excessive utilization because of the availability and ease of testing. A primary finding of this study was the low rate of utilization. Although POCT equipment was available for all transports over the 6 years, testing was performed in only 17% of cases. Rates were higher in patients with high acuity than for patients with more stable conditions. The annual rate of use was relatively constant, and rampant overuse of laboratory testing in this environment clearly did not occur for this testing program.

In many clinical settings, POCT has been reported to improve patient care (7–12). One of the most controversial aspects of POCT is the cost (7, 8, 10, 11). In the intensive care unit, it may not be cost-effective to use POCT when a substantially less expensive central laboratory test is available. In the transport setting, the issue is the cost of POCT vs no testing at all. We found that POCT represents a very small fraction of overall transport costs and a relatively small cost per case considering the potential for significant clinical benefit.

POCT has a unique niche in critical care transport, and our experience shows that testing can be performed with high reliability. POCT provides the benefit of rapid analysis of critical analytes and blood gases in a setting where no other laboratory analysis is available. POCT in the transport setting is infrequent and is relatively inexpensive. This study demonstrated that the use of POCT led to changes in patient treatment 30% of the times when testing was performed.

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References

Use of Inductively Coupled Plasma Mass Spectrometry to Measure Urinary Iodine in NHANES 2000: Comparison with Previous Method, Kathleen L. Caldwell,1,2 C. Brook Maxwell,1 Amir Mukhmidov,1 Sam Pino,2 Lewis E. Bruwereman,2 Robert L. Jones,1 and Joseph G. Hollowell1 (1 Inorganic Toxicology and Nutrition Branch, Division of Laboratory Sciences, National Center for Environmental Health, CDC, 4770 Buford Hwy., NE, Mail Stop F18, Atlanta, GA 30341; 2 Section of Endocrinology, Diabetes, and Nutrition, Department of Medicine, Boston Medical Center, Evans Bldg., Room 201, 88 Newton St., Boston, MA 02118-2393; 3 Department of Pediatrics, University of Kansas Medical Center, 435 N. 1500 Road, Lawrence, KS 66049; * author for correspondence: fax 770-488-4609, e-mail Klc7@cdc.gov)

Urinary iodine (UI) concentrations directly reflect dietary iodine intake and consequently test biochemical assessment of the iodine status worldwide (1).

The Iodine Laboratory of the Division of Laboratory Sciences at the National Center for Environmental Health, CDC, measured the UI content of specimens as part of the National Health and Nutrition Examination Survey (NHANES) 2000 and will measure UI in the US population through future NHANES analyses, using inductively coupled plasma mass spectrometry (ICP-MS). In this report, we describe the ICP-MS laboratory method and compare that method with the established Sandell–Kolthoff (S-K) spectrophotometric method used in NHANES III.

The ICP-MS method described previously (2) was
modified for use in NHANES 2000 by adding alkaline diluents and rinses to measure UI as follows: urine samples and the urine iodide calibrator solutions were prepared just before analysis by dilution (1:49; 50 μL of sample/calibrator plus 2450 μL of diluent) with an aqueous solution of 10 mL/L tetramethylammonium hydroxide containing 10 μg/L Te as an internal standard. A peristaltic pump introduced the diluted samples into the spray chamber with an argon stream. The I⁺ and Te⁺ ions were measured at m/z 127 and 130, respectively (3). The diluent used to make the intermediate working calibrators was 1.0 g of analytical-reagent-grade sodium thiosulfate (Na₂S₂O₃) dissolved in 1000 mL of 18 MΩ·cm ultrapure water. (The water used for all dilutions and rinses in the ICP-MS method is ultrapure 18 MΩ·cm water; Millipore Corporation.) The wash solution was an aqueous solution of 1 mL/L Triton X-100 and 10 mL/L tetramethylammonium hydroxide. This solution was pumped into the sample-introduction system between samples to prevent carryover of the analytes of interest from one sample measurement to the next.

External standardization, with matrix-matched calibration solutions, was used. Na₂S₂O₃ was used as a reducing agent to stabilize iodide in the calibration solutions and intermediate working stock calibrators. The intermediate calibration solution was the standard diluent with aliquots added of the working stock standard (100 mg/L SPEX iodide solution or equivalent) in ultrapure water to yield final concentrations of 0, 10, 50, 100, 500, and 1000 μg/L. In this step, the aqueous intermediate working calibrators were added to diluent and base urine to matrix-match the working calibrators with the urine samples being analyzed. These solutions were analyzed along with the diluted patient urine samples for the purpose of external calibration. A blank diluent consisting of Na₂S₂O₃ (20 mg/L) and 18 MΩ·cm ultrapure water was added to all controls, blanks, and samples.

We used a Sciex 6100 ELAN® ICP-MS system (PerkinElmer Instruments), which uses a quadrupole mass analyzer. This was coupled to a Ryton spray chamber that uses a GemTip Cross-Flow II Ryton nebulizer for sample introduction. The analytical settings were similar to those published previously (3). A dwell time of 200 ms was used for both I⁺ and Te⁺. We used three replicate readings with one reading per replicate and 25 sweeps per reading. The applied RF power was 1.2 kW, and the argon nebulizer gas flow was typically 1.01 L/min. Data acquisition was with ELAN software, Ver. 2.2,® with the Microsoft Windows NT® operating system. The limit of detection for UI by ICP-MS was 1.0 μg/L. The SD for a low-normal pool (79.6 μg/L) analyzed for 9 months in 20 separate analytical runs was 1.7 μg/L. Recovery by ICP-MS was 97.5–99.0% over the reportable range of 1–1000 μg/L. The ICP-MS and S-K spectrophotometric methods are compared in Fig. 1A. Differences between the two methods were concentration-dependent. The agreement between UI results obtained by ICP-MS and those obtained by the S-K method (Fig. 1B; Spearman correlation coefficient, 0.309; P = 0.0023). The difference between the mean results obtained with ICP-MS and the S-K method was not significant (3.7 μg/L; 95% confidence interval, −10.6 to 3.2 μg/L). The central 2 SD interval (Fig. 1B) gave an indication of the

![Graph showing UI values obtained by CDC with the ICP-MS method and by BMC with the S-K method (A), and Bland-Altman difference plot showing that the differences between the ICP-MS and S-K methods are concentration-dependent (B).](image-url)
agreement between the two methods. Ninety-five percent of the ICP-MS results were between −70.0 and 62.6 μg/L of the S-K results. The direction of difference between the two methods depended on the individual’s UI concentration (Fig. 1B); the results of Deming error-in-variables regression of ICP-MS on the S-K method were as follows: y-intercept, −19.041 μg/L; slope, 1.0655. At lower concentrations (<250 μg/L), UI measured by the S-K method was 2.7–15.8 μg/L higher than the sample measured by ICP-MS. The difference was inversely related to the iodine concentration of the sample measured.

Although there was a strong correlation between the two methods ($r^2 = 0.980$) and the average difference between the iodine results from the two laboratories was not statistically different, the results from the current NHANES studies should be compared directly with results from NHANES III only with caution after considering the concentration-dependent differences in the two methods.

Measuring UI accurately and precisely is important to ensure quality while monitoring the status of iodine nutrition of populations around the world. In the US, ICP-MS is the method used to measure UI in current and foreseeable populations sampled by NHANES. The ICP-MS method used at CDC provides a stable method, equally as precise as the method used in NHANES III.

At this time, only the median UI concentration for the total US population has been released. That value, 161.6 μg/L (7), indicates generally that the median UI of the US has not decreased since NHANES III (8) and suggests that nutrition for the country remains adequate according to the WHO definition of adequate iodine nutrition for a population (9). The status of iodine nutrition in the US will continue to be monitored by measuring UI in the ongoing NHANES, using ICP-MS.

The ICP-MS UI method is fast and accurate, offers precision that is equal to other methods, enables easier sample preparation, and has the potential for simultaneous multi-element analysis. Because of the ruggedness, accuracy, precision, and speed of the method and its ability to be coupled to multi-element analyses, CDC was able to measure UI in NHANES 2000 with existing resources. The limitations of the method are largely the cost and availability of startup equipment, initial supplies, and consumables and the expertise needed for operation and maintenance. Additionally there is a lack of primary matrix-matched reference material for UI by which all methods can be compared.

ICP-MS adds another tool for validation and reference in the process of monitoring the elimination of iodine deficiency disorders in the world. We do not recommend that other methods of measuring UI be abandoned, but instead that ICP-MS be used as a resource for quality assurance and improvement.

Mention of company or product names does not constitute endorsement by the National Center for Environmental Health (NCEH), CDC, or the Public Health Service.

References