Dried Urine and Blood Spot Analysis of Essential and Toxic Elements by ICP-DRC-MS with an Emphasis on Inter-Assay Stability of Samples Kept at Room Temperature

Theodore T Zava
ZRT Laboratory, Beaverton, Oregon, USA

ABSTRACT

Background: Elemental analysis plays a key role in monitoring the health of individuals and populations around the world. The sensitivity and specificity of inductively coupled plasma mass spectrometry (ICP-MS) has allowed precise quantification of a broad range of elements using various sample types. The collection, storage, and transport of samples without preservatives at room temperature while maintaining accuracy would be advantageous for health surveys, specifically in remote areas without refrigeration. We aimed to validate an assay for and show the stability of essential and toxic elements in urine and whole blood collected on filter paper.

Materials and Methods: Our laboratory developed dried urine and blood spot elemental assays using Whatman 903 filter paper for sample collection and a Perkin Elmer NexION 3000 ICP-MS with Dynamic Reaction Cell Technology for analysis. We focused on elements that have shown clinical utility in population health surveys and wellness assessments. Analytes selected were iodine, bromine, selenium, arsenic, cadmium, mercury in dried urine, and zinc, copper, magnesium, selenium, cadmium, lead, and mercury in blood spot.

Methods/Procedures/Results

Dried Urine and Blood Spot Collection

Human urine and whole blood were collected on Whatman 903 filter paper by dipping the filter paper in a clean urine cup and by lancet finger prick, respectively (Figures 1 and 2). Urine and whole blood external calibrators from Sero, RECIPE, and Bio-Rad, with established values for all elements tested, and multi-element standards obtained from Inorganic Ventures were dried in the same manner. The samples were left to dry for 4 h and stored at room temperature.

Extraction and Element Analysis

Dried urine (6 punches) and dried blood spots (2 punches) were punched using a 6-mm hole punch into a fritted filter block which was placed on a deep 96-well block. For dried urine analysis, while two 6-mm punches and 0.55 mL of extraction solution were used for blood spot analysis. Dried urine and blood spot assays were run separately with established calibrators in a single run mode using feluxin, and employing a micro-flow pump and nebulizer to make effective use of the small sample volume.

Assay Validation and Sample Stability

Inter-assay and intra-assay precision, linearity, spike recovery, limit of quantification, and accuracy were tested, with an emphasis on the stability of room temperature inter-assay samples.

Discussion/Conclusion

Validation of the dried urine and blood spot assay method was successful. Dried samples are stable for at least 1 month at room temperature. Dried samples are ideal for both individual analysis and population surveys in both urban and remote areas due to simple collection that is stable during shipping without the need for preservatives or refrigeration and reduced storage space. Care must be taken to prevent contamination of the filter card, and supplies/equipment used for sample processing must be free of all analytes of interest. Proper collection of dried blood spots is essential, as double spotting or small blood drops can affect results. Dried sample analysis has changed the way samples can be collected, transported, processed, and stored, paving the way for a new era in laboratory analysis.

Reference