Laboratory Procedure Manual

Analyte: **Urinary Creatinine**

Matrix: **Urine**

Method: **Beckman Synchron CX3 Clinical Analyzer**

Method No.:

Revised:

as performed by: University of Minnesota

Contact: Dr. Blanche Chavers

Important Information for Users

The University of Minnesota Laboratory periodically refines these laboratory methods. It is the responsibility of the user to contact the person listed on the title page of each write-up before using the analytical method to find out whether any changes have been made and what revisions, if any, have been incorporated.

Public Release Data Set Information

This document details the Lab Protocol for testing the items listed in the following table

File Name	Variable Name	SAS Label
ALB_CR_E	URXUCR	Urinary creatinine (mg/dL)
	URXUCRSI	Urinary creatinine(µmol/L)

There was a change in instruments in 2008. In 2007 the Beckman Synchron LX20 was used and in 2008 the Beckman Coulter UniCel® DxC800 was used. The methods used in 2007 are described in a separate document

SUMMARY OF TEST PRINCIPLE AND CLINICAL RELEVANCE

A Jaffé rate reaction, in which creatinine reacts with picrate in an alkaline solution to form a red creatinine-picrate complex, is used for creatinine analysis and is measured with a CX3 analyzer. The rate of the color development is measured 25.6 seconds after sample injection at 520 and 560 nm. The rate difference between the two wavelengths is proportional to the concentration of creatinine in the reaction cup. The procedures described below are included in the standard protocols of the Fairview University Medical Center (FUMC) (1–5).

Creatinine is the waste product derived from muscle creatinine and is released into the blood at a relatively constant rate. The amount of creatinine per unit of muscle mass is constant; therefore, increased blood creatinine is the best indicator of impaired kidney function. Measurements of blood creatinine (and also blood urea nitrogen) are used primarily to assess renal function. The ratio of urine albumin to urine creatinine is used to predict nephropathy risk in diabetic patients. (For the NHANES IV survey, urine creatinine is used as a reference analyte against which are measured other urine analytes, such as pesticides and heavy metals, and urine albumin/creatinine ratio).

1. SPECIAL SAFETY PRECAUTIONS

A. Follow all procedures and policies in the FUMC Laboratory Safety Manual, including the Universal Blood and Body Substance Technique (UBBST). Consider all specimens received for analysis potentially positive for infectious agents.

B. Wear gloves, lab coat, and safety glasses while handling all specimens. Dispose analyzed specimens and contaminated supplies in autoclave/biohazard bags; seal and autoclave. Wipe all work surfaces with disinfectant solution.

C. Recommend to laboratory personnel performing the assay that they receive the HBV vaccine. Maintain records of vaccination or signed declination forms.

D. Label all reagents indicating the preparation date, expiration date, formula, lot number if applicable, hazards of the reagent, antidote of contact with hazard, and the initials of the technician.

E. Note the location of the Material Safety Data Sheets (MSDS) for picric acid, sodium hypochlorite, and ethanol: room UH3-555 CC1 paperwork area.

F. Use special care when handling picric acid. Avoid contact with skin. Flush with copious amounts of water any spills and reagent bottles before disposing.

2. COMPUTERIZATION; DATA SYSTEM MANAGEMENT

A. Computerization

The CX3 analyzer evaluates calibration against preset ranges and is programmed for the analysis of controls and test specimens. The results are printed when all the samples that were programmed are completed. Results are reported from the CX3 analyzer in mg/dL.

B. Data System Management

The integrity of specimen identification is maintained through a two-step verification process. A collection list and specimens in numbered analyzer cups that corresponds to NHANES IV specimen identification is obtained from the Microalbumin Laboratory. This corresponding specimen number is entered in the CX3. The CX3 printout results are entered manually onto the collection list. A technologist reviews result data prior to result verification and release. NHANES IV results are available to the Microalbumin Laboratory within 36 hours via hard copy. The electronic transmission of results to NHANES IV is the responsibility of the Microalbumin Laboratory. Storage of the original CX3 printouts is located near the instrument. The data is stored on the computer drive, organized in notebooks, and located in the Microalbumin Laboratory.

3. SPECIMEN COLLECTION, STORAGE, AND HANDLING PROCEDURES; CRITERIA FOR SPECIMEN REJECTION

A. Specimen Collection Procedure

(1) Timed or random urine collections are obtained from study subjects as per study protocols.

(2) No special instructions such as fasting or special diets are requested.

(3) The optimum specimen volume is 1 mL, and the minimum acceptable volume is 75 µL.

(4) For the NHANES IV survey 250 µL of urine in 0.5-mL capped analyzer sample cups is received from the Microalbumin Laboratory for creatinine analysis. A collection list accompanies all specimens.

B. Specimen Storage Procedure

(1) Store aliquots in analyzer sample cups at 2–8°C until analysis.

(2) Complete analysis within 36 hours of receipt.

(3) Discard specimens after analysis.

C. Specimen Handling Procedure

(1) Handle all urine specimens as if they are capable of transmitting any infectious agent.

(2) Record notation of unusual appearance such as blood, precipitate, or color prior to analysis.

D. Criteria for Specimen Rejection

(1) Corrupted specimen integrity; cracked or leaking tube, unreadable or missing label.

(2) Note: Angiogram/IVP dyes do not interfere with analysis.

(3) Note: Acidified urine specimens are acceptable.

4. PROCEDURES FOR MICROSCOPIC EXAMINATIONS; CRITERIA FOR REJECTION OF INADEQUATELY PREPARED SLIDES

Not applicable for this procedure.

5. EQUIPMENT AND INSTRUMENTATION, MATERIALS, REAGENT PREPARATION, CALIBRATORS (STANDARDS), AND CONTROLS

A. Equipment and Instrumentation

(1) Milli-Q deionized water system (Millipore Corporation, San Antonio, TX).

(2) Beckman Synchron CX3 clinical analyzer (Beckman Instruments, Inc., Brea, CA). Hot Line 1-800-854-3633; Field Service 1-800-345-0424.

B. Materials

(1) Type 1 water, deionized and distilled, Milli-Q (Millipore).

(2) Sodium hypochlorite (bleach) solution 5% (v/v), cat. no. CX23880 (C295 Mayo Storeroom, Minneapolis, MN). Stable indefinitely at 20–25°C. Store for 2 years. CAUTION: Corrosive and irritant.

(3) Ethyl alcohol (C2H5OH) 95% (v/v), 1-L bottle, (L265 Solvent Storage Room). Store supply in flammable section under UH3-555 hood. Stable indefinitely at 20–25°C. Store for 2 years. CAUTION: Flammable.

(4) Wash solution concentrate, 6 x 250-mL kit, cat. no. 443335 (Beckman Instruments, Inc.). Contains bacteriostat and other nonreactive ingredients. Store at 20-25 °C until expiration date.

(5) Creatinine Reagent (contains two components to be mixed: 0.05 mol/L picric acid and alkaline buffer 0.188 mol/L sodium hydroxide (NaOH) buffered with sodium borate (Na2B4O7), sodium phosphate (NaH2PO4) and other nonreactive ingredients, 3 x 2000-mL kit, cat. no. 443340 (Beckman Instruments, Inc.). Store at 20-25 °C until expiration date.

CAUTION: Avoid contact with skin. If spilled, flush with copious mounts of water.

(6) Analyzer sample cups, polystyrene, conical, 0.5-mL capacity, 1000 cups/bag, cat. no. 339-788 (Curtin-Matheson Scientific, Inc., Eden Prairie, MN).

(7) Syringe, sterile 5-cc disposable, 100/pkg, cat. no. 301603 (Becton-Dickinson, Inc., Franklin Lakes, NJ).

(8) Luer-tip cap, 10/pkg (Becton-Dickinson, Inc.).

(9) General laboratory supplies: gloves, lab coats, safety glasses, disinfectant, autoclave bags, transfer pipettes (C295 Mayo Storeroom).

(10) Calibrator I, cat. no. 443360, and Calibrator II, cat. no. 443365 (Beckman Instruments, Inc). Store at 2–8°C unopened until expiration date.

(11) Moni-Trol XL Levels 1 and 2 liquid chemistry controls, cat. no. B5120-1 and B5120-2 (Dade International, Inc., Miami, FL). Store at –20°C unopened and protected from light until expiration date.

(12) Lyphochek Level I quantitative human urine control, item no. C-390-10 (Bio-Rad, Richmond, CA). Store the lyophilized product at 2–8°C unopened until expiration date.

(13) Creatinine Reference Material, NIST SRM 914A (National Institute of Standards and Technology, Gaithersburg, MD).

C. Reagent Preparation

(1) Wash Solution

Dilute 250 mL of wash concentrate to 10 L with Type 1 water. Mix well, then cap loosely to degas the solution for 24 hours prior to use. Store at 20–25°C for 1 month.

After using the wash solution bottle, rinse it with 70% ethanol, followed by Type 1 water. Allow the bottle to dry completely before re-using.

(2) Creatinine Reagent

Add picric acid bottle to buffer diluent. Degas for 2–4 hours (leave the cover off). Store at 20–25°C for 1 month.

CAUTION: Avoid contact with skin. If spilled, flush with copious mounts of water.

(3) Sodium hypochlorite (bleach) solution, 2% (v/v)

Dilute 400 mL of 5% bleach to 1 L with Type 1 water. Store at 20–25°C for 2 years.

CAUTION: Corrosive and irritant.

(4) Ethyl alcohol 70% (v/v)

Dilute 700 mL of 95% ethyl alcohol to 1 L with Type 1 water. Store at 20–25°C for 2 years.

CAUTION: Flammable.

D. CALIBRATORS (Standards)

(1) Standard line calibration material: aqueous creatinine calibrator

The calibrators are ready-to-use. Store at 20–25°C after date of opening for 1 month. Perform a comparability study for new lot numbers of calibrators:

(a) Calibrate using the current (old) lot of calibrators.
(b) Run the current and new lot numbers of aqueous calibrators (i.e., alternating between them) five times each.
(c) Average the result of each lot number.
(d) Divide the average of the new lot number by the average of the old lot number and multiply by 100.
(e) The acceptable limit is 100 ± 1%.

Return calibrators to the manufacturer for replacement with a different lot if the results of calibrator comparisons are not within the acceptable limit.

(2) Primary standard reference material

The primary calibration standard is “NIST SRM 914A Creatinine”. Calibrators I and II are referenced against this material.

(3) Controls

Four levels of commercially prepared control material are used for quality control. The approximate creatinine concentrations of these four levels are 1, 5, 20, and 100 mg/dL.

(4) Quality control material for concentrations 1 and 5 mg/dL are serum control: Moni-Trol XL liquid chemistry control Levels 1 and 2, respectively

Follow the instructions in the package inserts. Thaw one bottle, mix, and store the material at 2–8°C. in the dark for 14 days. Dispense aliquots as needed for analysis.

(5) Quality control material for 20 and 100 mg/dL are urine control: Lyphochek Level I used at dilution 1:5 and 1:1, respectively.

Follow the instructions in the package inserts. Reconstitute each vial with 10.0 mL of Type 1 water. Allow the solution to stand for at least 15 minutes, swirling occasionally and gently inverting the vial several times to ensure homogeneity. Aliquot the entire vial contents into 0.5-mL analyzer sample cups, cap the cups, and freeze at –20°C for up to 1 month. Thaw aliquots as needed for analysis. Once the control is reconstituted it is stable for 5 days when stored tightly capped at 2–8°C.

6. CALIBRATION AND CALIBRATION VERIFICATION PROCEDURES

A. Calibration Procedure

For each assay calibrate the CX3 analyzer. Calibrators I and II have creatinine concentrations of, 5 mg/dL and 0 mg/dL, respectively. They are used to prepare a linearized 2-point standard curve with a range of 0–400 mg/dL. To calibrate creatinine, place fresh cups of Calibrators I and II in cup positions 1 and 2, respectively. Press CAL. From the master screen, select the following menu items: F3 (CAL), F1 (REQUEST CAL), and enter the analytes to be calibrated: select CREATININE. The CX3 primes each channel twice, then samples and analyzes each calibration solution at least twice. The CX3 evaluates the calibration by comparing the analog-digital count (ADC) number to the preset ranges.

The instrument evaluates calibration against the preset ranges as shown in Table 1.

Table 1. Acceptable Ranges for Calibrators

Parameter	ADC Range
Calibrator I	–530 to –300
Calibrator II	–25 to 25
Span of Calibrator I and II	≥250
Difference of duplicates for each calibrator	≤16

If an analyte is imprecise, a third or fourth replicate of the standard will be measured. If any calibration fails, the beeper alarm will sound.

If calibration is interrupted, the beeper alarm will sound. Press the STATUS button for a message explaining the interruption. Press the HOME button and, when the green light quits flashing, proceed with a new calibration. Acceptable range, precision, and sensitivity limits for ADC numbers are found under F3(CAL), F3(CAL DATA DISPLAY).

Creatinine calibration lasts 8 hours. If the reagent is replaced or maintenance/troubleshooting is performed, prime and recalibrate the instrument.

B. Calibration Verification Procedure

(1) Verify the validity of new standards with a minimum of five overlapping assays performed with existing standards. When quality control values in all five assays using the new standard lots meet acceptable criteria, the new standards are included in assay runs.

(2) Verify that the 4 quality control samples are within the expected 95% limits as described by Westgard rules.

(3) Verify against “NIST SRM 914A Creatinine”, a reference material of known value.

7. PROCEDURE OPERATING INSTRUCTIONS; CALCULATIONS; INTERPRETATION OF RESULTS

A. Procedure Operating Instructions

Preliminaries on the assay day

(1) Record reagent dates and lot numbers and perform daily start-up maintenance:

(2) Check reagent levels.

(3) Check drain lines. Dispose of waste.

(4) Check the red heater lamp on the creatinine module; the heater lamp lights when the module reaches the correct temperature.

(5) Check the source lamp on the creatinine module and check for bubbles in the creatinine module.

(6) Prime the chemistries and check the following:

(a) Inspect the reagent and drain lines for crimps, loose connections or leaks.

(b) Observe peri-pump action.

(c) Determine that the reaction cups are draining, filling, sipping and stirring properly.

(d) Verify the up/down movement of the ratio pump. Check for excess bubbles in the ratio pump chambers. To remove bubbles from a chamber:

F4 (Special Function)
F2 (Prime)

F3 (Ratio Pump)
Press ENTER
Then enter the number of primes and press ENTER.

While the pump is in the downward motion, clamp off the even number tube to the desired chamber. When the pump almost reaches the bottom, release the clamp. The bubbles should be dislodged and exit the odd number tubing when the pump moves upward.

B. Sample Preparation on the assay day

Uncap analyzer sample cups and place in analyzer. Do not mix.

C. Instrument Setup on the assay day

Set up and calibrate the CX3 analyzer for creatinine as described in Section 7.

D. Operation of Assay Procedure

(1) Pipette 50 µL of control or test specimens into analyzer sample cups. To prevent evaporation, do not load more than five samples in advance. Cups are sampled every 60 sec when all tests are requested.

(2) To program the tray, press F1 (SAMPLE PROGRAM) to enter the tray number. Cups 1–80 are available for test programming.

(3) To program the analysis of controls, enter the control "number" under SAMPLE ID, enter "creatinine" under CHEMISTRIES, enter "control" under SAMPLE TYPE. Analyze two levels of serum controls after each calibration to verify the calibration. Analyze urine controls whenever urine unknowns are analyzed. Analyze one of the four levels of control after a minimum of 10-15 samples alternating them throughout the run.

(4) To program the analysis of specimens, enter the specimen number, press ENTER, CREATININE, ENTER, URINE. If an error is made, press CLEAR to clear the entire line.

(5) When five specimens are programmed, press F8 to return to the master screen, press START. To continue programming as specimens are analyzed, repeat steps 2-4.

(6) When the CX3 completes all samples programmed on a tray, the message "Program for this tray completed" is displayed, the results are printed and the instrument returns to standby mode.

(7) The instrument has memory for two trays. To clear a completed tray from the master screen, press CLEAR, then enter tray number to be cleared. Trays are identified as 1–99.

(8) Record all dilution factors or any pertinent specimen information on the protocol pages.

(9) Results of duplicate tests of sample urine specimens should be within 4 mg/dL. Report the original result rather than averaging two results when duplicate results are within 4 mg/dL.

(10) Recap analyzer sample cups immediately to maintain sample integrity for repeat analysis, if needed.

E. Replacement and Periodic Maintenance of Key Components CX3 Analyzer - Weekly Maintenance

(1) Clean sample trays and covers, also the chemistry cup area with disinfectant.

(2) Clean the creatinine cup and stirrer with Type 1 water. (Operator's Manual, Para. 5.4.4).

(3) Inspect the in-line filters and reverse flush with Type 1 water. (Operator's Manual, Para. 5.3.3).

(a) Press STOP to prevent auto prime.

(b) Remove filter and perform reverse flush if necessary.

(c) Replace the filters at least every 8 weeks or when debris cannot be removed. Replace filters with arrows pointing upward.

(d) Press HOME.

(4) Move the tubing in the E and C pinch valves slightly right or left. Massage the tubing while moving. (Operator's Manual, Paragraph. 5.3.4). Note: The CX3 should be in the E cam maintenance screen. Loosen only one bar at a time.

F. CX3 Analyzer - Periodic Maintenance

(1) Perform 4-, 8-, and 12-week maintenance as directed in the operator's manual.

(2) Refer to the CX3 Operating and Service instructions for troubleshooting procedures.

(3) Further assistance can be obtained from the Beckman Hotline (1-800-854-3633) or Beckman Field Service (1-800-845-0424).

(4) Notes: Never place metal objects in the creatinine analysis cup and be careful when removing the stirrer as the optical surfaces facing the cup are easily scratched.

G. Pipettors - Periodic Maintenance

Calibrate and clean all pipettors every 6 months. Pipettors not conforming to specifications are autoclaved and mailed for recalibration in accordance with the manufacturer's recommendations. Calibration records are kept for each pipettor by serial number.

H. Calculations and Interpretation of Results

The CX3 analyzer is programmed to compute a linearized 2-point standard curve and with a range of 0–400 mg/dL. Test results and qc levels are reported from the CX3 in mg/dL. Recorded values for the 4 quality control samples on the Levy-Jennings charts determine satisfactory assay performance.

8. REPORTABLE RANGE OF RESULTS

A. The range of linearity for urine creatinine analysis is 0–400 mg/dL.

B. Reanalyze urine specimens with values <10 mg/dL on the serum channel.

C. Reanalyze urine specimens that have creatinine results >400 mg/dL after dilution with Type 1 water.

D. Report values <1.0 mg/dL as <1 mg/dL.

E. The lower limit of detection for the assay is 1 mg/dL; there is no upper limit of detection. Therefore, the "reportable range of results" is "1mg/dL and up" or "≥ 1 mg/dL".

9. QUALITY CONTROL (QC) PROCEDURES

A. Quality Control System

Internal QC procedures monitor analytical performance relative to medical goals and alert analysts to unsatisfactory analytical performance. Estimates of imprecision and permanent confidence limits are generated from 50-pair data or more (50 assay days) of four control pool levels. Calculated from the 50-pair data are the % CV (percent correlation of variance), the SDo (standard deviation overall), and the duplicate range (average of the differences between duplicates, average R). Tolerance limits for controls are established by using the Westgard Rules5 as guidelines. The tolerance limits are defined as the mean ±2 SDo, or 95% warning limit, and the mean ±3 SDo, or 99% action limit. When new control urine pools are initiated into the assay, the new mean is established from 20-pair data (20 assay days) and analyzed with the older controls during this time period. Calculations from these 20-pair (% CV, SDo, and duplicate range) are used only to monitor the 50-pair permanent confidence limits. Four (low to high) range bench quality control pool samples are analyzed in each analytical run (a set of assays performed on a given day) so that judgments may be made on the day of analysis. The four control samples are the same in all assays.

Prepare a Levy-Jennings Means Chart for each of the four urine pool levels. Chart the means and tolerance limits on the graph paper. The four levels of control are each analyzed singly at the beginning at the end of every assay run. Also, after every 10–12 unknown specimens one of the four controls is analyzed, alternating throughout the assay run. The single value of each of the four levels of control from either the beginning or the end of the assay run is reported to NHANES. Two or more dots are plotted on the Levy-Jennings charts. On this chart highlight unacceptable control values and action taken, document reagent changes and other pertinent information. Prepare a cumulative table of duplicate values and the difference between duplicates for the four control urine samples. Highlight unacceptable duplicates according to the within batch duplicate range (average R) tolerance limits and make notation on the Levy-Jennings charts. If the assay is determined to be out of range, perform function checks on the reagents and instrumentation. Provide assay results only after problems are corrected. The Levy-Jennings charts are reviewed and signed daily by testing personnel and quarterly by the clinical chemistry laboratory supervisor. (For NHANES IV, copies are mailed for review by the project officer.)

The system is declared "out-of-control" if any of the following events occur on the Means Chart:

A single run mean for one or more pools falls outside the upper or lower 99% limit.

The run means for two or more pools fall either both above or both below the 95% limit.

Two successive run means for a single pool fall either both above or both below the 95% limit.

Eight successive run means for a single pool fall either all above or all below the centerline, establishing a trend.

The system is declared "out-of-control" if any of the following events occur on the Range Table:

A single within-run range falls above the upper 99% limit.

The within-run ranges for two or more pools fall above the upper 95% limit.

Two successive within-run ranges for a single pool fall above the upper 95% limit.

Eight successive within-run ranges for a single pool fall above the center line.

B. Quality Assurance System

A “Continuous Quality Improvement Plan and Documentation” program is in effect for the laboratory. General QA systems are in operation to detect errors, monitor tolerance limits on temperatures, ensure proper reagent labeling and equipment maintenance. The laboratory ensures that samples are collected, handled, shipped, preserved and stored correctly, and rejected if the criteria are not met.

C. External Proficiency Testing

College of American Pathologists (CAP) specimens are used for proficiency testing to evaluate assay performance. Individual study protocols may include blinded split duplicate test specimens to externally evaluate the assay performance. (For the NHANES IV, the laboratory monitors the inter-assay variation by repeating 2% of the specimens from the previous assay.)

D. Accreditation

The laboratory is certified by the Clinical Laboratory Improvement Act (CLIA), the College of American Pathologists (CAP), and the Joint Commission for Accreditation of Healthcare Organizations (JCAHO).

10. REMEDIAL ACTION IF CALIBRATION OR QC SYSTEMS FAIL TO MEET ACCEPTABLE CRITERIA

A. Discontinue testing until the problem is resolved and both calibration and QC meet acceptable criteria.

B. Report patient results only when runs are in statistical control.

C. Document all actions and information (i.e., reagent changes, instrument problems, etc.) relating to the "out-of-control" run.

12. LIMITATIONS OF METHOD; INTERFERING SUBSTANCES AND CONDITIONS

A. Limitations of Method (false-positive results)

(1) Substances causing false-positive creatinine results are; lithium bromide, acetoacetate, acetone, glucose at levels 2000 mg/dL (it falsely elevates creatinine results by 25%), ammonium chloride, M-dopa at levels 200 µg/mL (it falsely elevates creatinine results by 0.6 at a level of 2.0 mg/dL), and sodium pyruvate.

(2) Acetoacetate levels of 0.25 mmol/L (normal = 0.05-0.15 mmol/L). This corresponds to a "trace-positive" Ketostix (ketone screen) and will falsely elevate creatinine values by 0.8 mg/dL at a 2.0 mg/dL creatinine level. Creatinines should be analyzed on the VITROS for all samples with a positive ketone screen. (Note, the VITROS procedure is not applicable for NHANES as results from other analytes are unknown.)

(3) Acetone level of 100 mg/dL. Although this problem would be rarely encountered, acetone falsely elevates creatinine value by 0.4 mg/dL at a 1.1 mg/dL creatinine level.

(4) Cephalosporin levels of 300 µg/mL. This drug concentration will falsely elevate creatinine values by 1.1–1.5 mg/dL at a 1.1 mg/dL creatinine level. Higher levels of cephalosporin will cause a proportionally higher interference. (The current Physicians Desk Reference states that cephalothin and cefoxitin concentrations >100 µg/mL may interfere with test results, and serum samples should not be analyzed for creatinine if drawn within 2 hours of drug administration. It is advisable that patients have their blood drawn for creatinine tests immediately before the next dose of cephalosporin. Because of the potential interference, it is crucial to assess the BUN and creatinine fluctuations and investigate further, as this is the only way to discover the problem.)

B. Limitations of Method (false-negative results)

(1) Factors causing false negative creatinine results are gentistic acid at levels 20 mg/dL (it falsely lowers creatinine results by 0.5 at a level of 2.2 mg/dL), bilirubin, lipemia, hemolysis, and L-dopa at levels 250 µg/mL (it falsely lowers creatinine results by 0.6 at a level of 2.0 mg/dL).

(2) A hemoglobin level >750 mg/dL. Gross hemolysis falsely lowers the creatinine level.

See Synchron advisory (2) for further list of substances interfering with Beckman Chemistries. Specimens having listed interferences on the CX3 should be analyzed on the VITROS and results reported. (Note, the VITROS procedure is not applicable for NHANES IV survey.)

13. REFERENCE RANGES (NORMAL VALUES)

Although urine creatinine concentrations are very dependent upon skeletal muscle mass, approximate normal ranges (based on 24-hour urine collections) are presented in Table 2.

Table 2. Normal Ranges for Urine Creatinine

Age, years	Range per day
2-3	6-22 mg/kg/d
4-16	12-30 mg/kg/d
≥16, male	1.0-2.0 g/d
≥16, female	0.8-1.8 g/d

14. CRITICAL CALL RESULTS (PANIC VALUES)

No medical intervention is indicated for unusual urine creatinine results on random urine specimens.

15. SPECIMEN STORAGE AND HANDLING DURING TESTING

Store specimens at 2–8°C until analysis. Specimens reach room temperature during analysis. Complete testing within 36 hours of receipt in the laboratory.

16. ALTERNATE METHODS FOR PERFORMING TEST OR STORING SPECIMENS IF TEST SYSTEM FAILS

A. The CX3 analyzer is exclusively used for analysis of NHANES IV survey urine creatinines. The VITROS analyzer is used only for those specimens that are shown to contain substances that may interfere with the CX3 chemistry. Therefore, the VITROS procedure is not applicable for NHANES IV as results from other analytes are unknown to the laboratory.

B. In the event of instrument malfunction or unacceptable calibration or QC, samples are returned to 2–8°C.

C. If the system is inoperable >36 hours, fresh urine aliquots in analyzer sample cups are requested from the Microalbumin Laboratory. Specimens in the original NHANES IV tubes may be refrozen until analysis is possible.

17. TEST RESULT REPORTING SYSTEM; PROTOCOL FOR REPORTING CRITICAL CALLS (IF APPLICABLE)

A. Test Result Reporting system

(1) Results from the CX3 printout are hand-written onto the accompanying collection list and returned to the Microalbumin Laboratory for electronic transmission to NHANES IV.

(7) The creatinine test result is reported in mg/dL to the nearest whole number.

B. Protocol for reporting critical calls

Not applicable for this procedure.

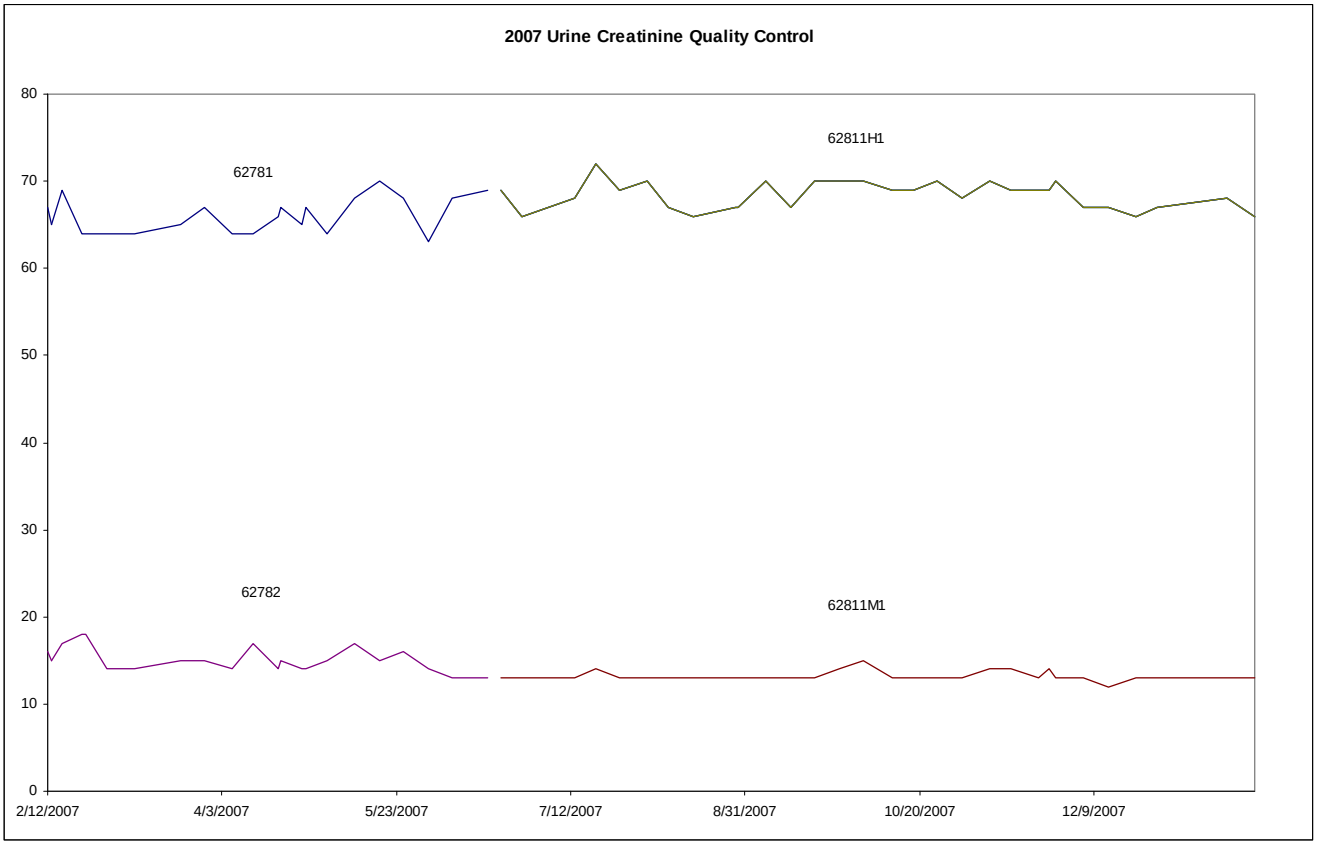
18. TRANSFER OR REFERRAL OF SPECIMENS; PROCEDURES FOR SPECIMEN ACCOUNTABILITY AND TRACKING

Shipments of frozen specimens are logged in upon receipt by the Microalbumin Laboratory. Aliquots in analyzer sample cups and accompanying collection lists are transferred to the Creatinine Laboratory by the Microalbumin Laboratory personnel. Specimens in the original tubes are re-frozen at –70°C and returned on dry ice to the NHANES IV contract storage facility McKesson Bioservices by the Microalbumin Laboratory. All notebooks, disks, and files containing raw data, final data, QC information, communications, etc. are saved. These serve as documentation for specimen accountability and tracking.

SUMMARY STATISTICS AND QC GRAPHS

Summary Statistics for Urine Creatinine by Lot

Lot	N	Start Date	End Date	Mean	Standard Deviation	Coefficient of Variation
62782	23	2/12/2007	6/18/2007	15.1	1.5	9.8
62781	23	2/12/2007	6/18/2007	65.9	2.1	3.1
62811M1	30	6/22/2007	1/24/2008	13.2	0.6	4.2
62811H1	30	6/22/2007	1/24/2008	68.4	1.6	2.3



REFERENCES

1. Operating and Service Instruction, Beckman Synchron CX3 Clinical System, Beckman Instruments, Inc., Brea, CA.
2. Advisor Synchron Users Club, Beckman Synchron CX3 Clinical System, Beckman Instruments, Inc., Brea, CA.
3. Tietz NW, ed. Textbook of Clinical Chemistry. Philadelphia: WB Saunders Company, 1986. pp. 775–1392.
4. Kaplan LA, Pesce AJ, editors, Clinical Chemistry Theory, Analysis and Correlation. St. Louis: CV Mosby Company, 1984. pp.416–1261.
5. Westgard JO, Carey RN, Wold S. Criteria for judging precision and accuracy in method development and evaluation. Clin Chem. 1974;20:825–833.