Comparison of Three Whole Blood Creatinine Methods for Estimation of Glomerular Filtration Rate Before Radiographic Contrast Administration

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**Abstract**

We compared the clinical concordance of estimated glomerular filtration rate (eGFR) based on 3 whole blood creatinine assays with the eGFR calculated from a reference plasma creatinine assay. Whole blood creatinine on the Radiometer ABL800 FLEX (Radiometer A/S, Bronshoj, Denmark) demonstrated the best correlation and concordance to plasma creatinine/eGFR compared with the i-STAT (i-STAT, East Windsor, NJ) and StatSensor (Nova Biomedical, Waltham, MA). The i-STAT had better sensitivity (compared with Radiometer) but poorer specificity for prediction of plasma eGFR less than 60 mL/min/1.73 m^2_. The StatSensor demonstrated lower concordance of whole blood to plasma eGFR but offered a slope and an intercept offset feature that partially compensates for this effect. The optimal device for use in rapid determination of eGFR from whole blood creatinine may depend on whether it is more important in a given practice to optimize sensitivity, specificity, or overall concordance for determining plasma eGFR less than 60 mL/min/1.73 m^2_.

Chronic kidney disease is a major health problem affecting about 19 million persons in the United States.^1^ Owing to its increasing incidence, national recommendations now exist for estimation of glomerular filtration rate based on serum creatinine values, using the Modification of Diet in Renal Disease (MDRD) study equation.^2,3_ Estimation of the glomerular filtration rate from serum creatinine levels is particularly useful in situations requiring rapid evaluation and recognition of renal impairment, such as the case of patients undergoing procedures requiring administration of radiographic contrast media.^4_

In these cases, the estimated glomerular filtration rate (eGFR) is valuable in identifying patients at risk of developing contrast-induced nephropathy (CIN), a major cause of hospital-acquired renal failure and a significant cause of morbidity and mortality among hospitalized patients.^4_ Measurement of the serum creatinine level, with calculation of eGFR based on the MDRD equation, is strongly recommended as a means to identify patients at risk for CIN.^4_ Strategies such as alternative contrast agents, preventive therapies, and reduced contrast agent dose can be used if patients with renal impairment are identified before administration of a contrast agent. Some of these therapies are effective in reducing the incidence of CIN.^4,5_ For this reason, interest in rapid, whole blood creatinine assays for use at the point of care has increased, especially in institutions with a high volume of procedures requiring radiographic contrast media.

However, calculation of the eGFR from serum creatinine levels is not without limitations. Analytic bias and interferences in many commercially available serum or plasma creatinine assays is a source of major concern.^3_ The
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Effect of bias can be partially overcome by using different MDRD equations depending on the calibration traceability of the laboratory creatinine assay and reporting higher eGFR values as “more than 60 mL/min/1.73 m²” because creatinine assay bias impacts high (>60 mL/min/1.73 m²) eGFR estimations to a greater extent than it does lower values.2,3 Patients with eGFR less than 60 mL/min/1.73 m² are at higher risk of CIN, and for this reason, published guidelines recommend using the eGFR to identify at-risk patients.4 Whole blood creatinine assays for use at the point of care would be ideal for rapid estimation of the eGFR in patients needing radiographic contrast media and for other situations in which rapid determination of the eGFR would be useful. However, some whole blood creatinine methods have increased bias relative to central laboratory methods,5,7 which could make estimation of eGFR at the clinical decision point of 60 mL/min/1.73 m² even more problematic.

To lower the risk of CIN, patients scheduled for computed tomography (CT) examinations requiring contrast administration in our practice must have a documented creatinine/eGFR value available if they are older than 70 years, have a history of diabetes, or have a history of renal disease or renal transplantation. For patients scheduled for a CT examination who meet these criteria and do not have a current (within 30 days) creatinine/eGFR value available and patients who have a creatinine/eGFR value pending at the time of CT, a blood sample is sent to the stat laboratory for creatinine/eGFR measurement. In this study, we compared 3 whole blood creatinine methods with a laboratory plasma creatinine assay used as a reference method in 266 patients scheduled for CT examination who required a stat creatinine/eGFR measurement. Our goal was to determine the effect of bias on eGFR values available and patients with a pending creatinine/eGFR value at the time of CT, samples are sent to the stat laboratory for creatinine/eGFR measurement. Sample selection was not consecutive because staff was available only during selected hours to perform the whole blood creatinine testing. The study was conducted between November 1 and December 31, 2008. Creatinine values, patient age, sex, and ethnicity (African American or not African American) were recorded for each sample. The study design was approved by the Mayo Clinic Institutional Review Board (Rochester, MN).

Creatinine Methods

The reference method was the Roche enzymatic creatinine method performed on lithium heparin plasma on a Roche Cobas Integra 400 analyzer (Roche Diagnostics, Indianapolis, IN). This assay is calibrated to the recommended calibration standard based on isotope dilution mass spectrometry (IDMS).2,3 National Institute of Standards and Technology (NIST) Standard Reference Material 967-Creatinine in Human Frozen Serum (SRM 967) was used to validate the reference assay. Replicate (n = 5) measurements of NIST SRM 967 with assigned values of 0.8 and 3.9 mg/dL (71 and 345 μmol/L) resulted in mean (± SD) Roche enzymatic creatinine measurements of 0.8 ± 0.0 and 4.08 ± 0.04. Daily quality control at a target level of 0.8 mg/dL (71 μmol/L) demonstrated an interassay coefficient of variation of less than 4% during the study period. Thus, the Roche IDMS-calibrated plasma assay used for the study was a suitable reference method for plasma creatinine and eGFR determination, especially given that most samples tested in the stat laboratory have values between 1.0 and 2.0 mg/dL (88-177 μmol/L) creatinine.

Whole blood creatinine methods tested included the Radiometer ABL800 FLEX blood gas analyzer (Radiometer Medical A/S, Bronshoj, Denmark), which uses an amperometric biosensor (electrode) based on the enzymatic conversion of creatinine to creatine, then sarcosine, followed by a reaction that generates hydrogen peroxide from sarcosine.8 The i-STAT (i-STAT, East Windsor, NJ) and StatSensor (Nova Biomedical, Waltham, MA) handheld portable creatinine analyzers, which use similar chemical reactions to measure creatinine electrochemically,7 were also evaluated. For each whole blood method, linearity and precision were assessed by replicate analysis of linearity material and commercial control samples produced by each manufacturer. For the 266 patient samples evaluated, excess lithium heparin whole blood was removed after sample mixing to run on the i-STAT, StatSensor, and Radiometer methods (in that order) followed by centrifugation of the sample for 2 minutes at 3,500g for analysis of plasma creatinine on the Integra 400.

Materials and Methods

Sample Selection

For the study, 266 excess lithium heparin whole blood samples submitted for stat evaluation of creatinine/eGFR before contrast administration for CT procedures were used. Institutional protocol requires creatinine/eGFR measurement for patients older than 70 years, patients with a history of diabetes, and patients with a history of renal disease or renal transplantation. For patients meeting these criteria without a current (within 30 days) creatinine/eGFR value available and patients with a pending creatinine/eGFR value at the time of CT, samples are sent to the stat laboratory for creatinine/eGFR measurement.
Calculation of eGFR

For Roche Integra 400 and Radiometer ABL 800 FLEX measurements, the eGFR was calculated by using the MDRD equation adjusted for methods calibrated to IDMS traceability2:

\[
eGFR (\text{mL/min}) = 175 \times Cr^{-1.154} \times \text{Age}^{-0.203} \times 0.742 \text{ if female} \times 1.212 \text{ if African American}
\]

For i-STAT and StatSensor creatinine measurements, the eGFR was calculated by using the MDRD equation originally validated for use with conventional creatinine calibrations2,3:

\[
eGFR (\text{mL/min}) = 186 \times Cr^{-1.154} \times \text{Age}^{-0.203} \times 0.742 \text{ if female} \times 1.212 \text{ if African American}
\]

Data Analysis

Microsoft Excel (Microsoft, Redmond, WA) was used to calculate the eGFR for each patient sample based on whole blood or plasma creatinine levels and using the equations defined in the preceding sections. Microsoft Excel was also used for linear regression analysis of whole blood vs plasma (reference) creatinine levels and to calculate mean (±SD) bias for whole blood vs plasma creatinine levels. Bland-Altman plots were constructed to visually compare the relationship between whole blood and plasma creatinine for the range measured.

Sensitivity was defined as the number (percentage) of whole blood eGFR values that correctly predicted a plasma eGFR value of less than 60 mL/min/1.73 m². Specificity was defined as the number (percentage) of whole blood eGFR values that correctly predicted a plasma eGFR value of 60 mL/min/1.73 m² or more. This cutoff was chosen because published national guidelines suggest that patients with an eGFR of less than 60 mL/min/1.73 m² are at higher risk of developing CI and should be evaluated differently from patients with higher eGFR.4 Overall concordance was calculated as the number (percentage) of whole blood eGFR values that fell into the same category (≥60 or <60 mL/min/1.73 m²) as the corresponding plasma-based eGFR value. The McNemar test was used to assess the statistical significance of differences in sensitivity, specificity, and overall concordance for the 3 whole blood methods considered. A P value of less than .02 was considered statistically significant to account for multiple comparisons.

The StatSensor device offers users the ability to enter a slope and an intercept offset to match whole blood to plasma creatinine values. The manufacturer of the device recommends a simple fixed offset to match whole blood to plasma values within a narrow range of values. For this reason, we calculated eGFR concordance for StatSensor values with and without application of a fixed offset of 0.28 mg/dL (25 μmol/L) creatinine, which was the offset that maximized overall concordance between StatSensor whole blood and plasma eGFR values for the 266 sample data set.

Results

Linearity and Precision

Replicate analysis (n = 5) of linearity/calibration check material provided by each manufacturer demonstrated that all whole blood devices had a tendency to slightly overestimate creatinine levels at low concentrations and slightly underestimate creatinine levels at high concentrations. The StatSensor device demonstrated a mean recovery of 134% of the expected value when a commercial sample with an assigned value of 0.75 mg/dL (66 μmol/L) of creatinine was used. The i-STAT and Radiometer methods recovered 106% and 120%, respectively, of expected levels at similar creatinine values. All of the devices recovered 95% to 100% of expected values when linearity material with assigned values of 2 to 10 mg/dL (177-884 μmol/L) was used.

Daily quality control material provided by each manufacturer was used to assess interassay precision during the study period. All 3 devices demonstrated coefficients of variation between 3% and 7% when control materials with values between 1 and 5 mg/dL (88-442 μmol/L) of creatinine were used daily for 20 days.

Patient Demographics

Among the 266 patient samples collected, severe renal failure (plasma eGFR < 30 mL/min/1.73 m²) was present in 4 patients, whereas 25 patients had plasma eGFR between 30 and 50, and 48 patients had plasma eGFR between 51 and 60 mL/min/1.73 m². The mean (±SD) age of the patients was 68 ± 14 years (range, 22-92 years). There were 103 women and 163 men; 264 patients were not African American, and 2 patients were African American.

Relationship Between Whole Blood and Plasma Creatinine Values

The 266 patient samples were analyzed on all 3 whole blood devices and compared with plasma creatinine levels on the Roche Cobas Integra 400 used as the reference method. The mean (±SD) bias between StatSensor whole blood and plasma creatinine was −0.23 ± 0.18 mg/dL, indicating that the StatSensor whole blood method systematically underestimated plasma creatinine values. The mean bias between i-STAT whole blood and plasma creatinine levels was 0.13 ± 0.08 mg/dL, indicating slight overestimation of plasma creatinine by the i-STAT method. The Radiometer demonstrated a mean bias vs plasma creatinine level of −0.05 ± 0.09 mg/dL. Linear regression between whole blood and plasma creatinine levels resulted in the following relationships:

Y(StatSensor whole blood) = 0.59 × (plasma creatinine) + 0.18, \( r^2 = 0.61 \);
Y(i-STAT whole blood) = 0.95 × (plasma creatinine) + 0.18, \( r^2 = 0.93 \); and Y(Radiometer whole blood) = 0.95 × (plasma creatinine) + 0.00, \( r^2 = 0.89 \).
Bland-Altman plots of whole blood vs plasma creatinine are shown in Figure 1 and Figure 2. The StatSensor demonstrated a negative bias vs plasma creatinine for the range of creatinine values measured (Figure 1) and also demonstrated more variability in the relationship between whole blood creatinine and plasma creatinine levels compared with the i-STAT or Radiometer. The i-STAT had a constant positive bias for the range of creatinine values measured (Figure 1), whereas the Radiometer method had the smallest absolute bias relative to plasma creatinine for the range of values measured (Figure 2).

Clinical Concordance Between Whole Blood and Plasma eGFR Values

Whole blood and plasma creatinine values, along with patient age, sex, and ethnicity, were used to calculate the eGFR as defined in the “Materials and Methods” section. Overall concordance was calculated as the number (percentage) of all whole blood creatinine values falling into the correct plasma creatinine category (ie, <60 or ≥60 mL/min/1.73 m²). Because the StatSensor device offers users the ability to enter an offset to match whole blood to plasma creatinine values, we calculated eGFR concordance for StatSensor with and without a fixed offset of 0.28 mg/dL (see the “Materials and Methods” section).

The Radiometer analyzer displayed the best overall concordance with plasma creatinine (93%) Table 1. The sensitivity for the detection of plasma eGFR less than 60 mL/min/1.73 m² was 81%, whereas specificity was 97% (Table 1). All 13 patients with plasma eGFR less than 60 mL/min/1.73 m² misclassified by the Radiometer (whole blood eGFR reported as ≥60 mL/min/1.73 m²) had plasma eGFR values more than 45 mL/min/1.73 m² and plasma creatinine levels of 1.5 mg/dL (133 μmol/L) or less.

The i-STAT demonstrated a trend toward slightly lower overall concordance (87%) but had the best sensitivity (97%) for the detection of plasma eGFR less than 60 mL/min/1.73 m². The increased sensitivity of the i-STAT is a consequence of systematic overestimation of plasma creatinine owing to the inverse relationship between creatinine and eGFR values.

![Figure 1](image1.png) Bland-Altman plots for StatSensor and i-STAT whole blood creatinine values compared with reference plasma creatinine values (difference between whole blood and plasma creatinine values vs mean of whole blood and plasma value). Values are given in conventional units. To convert to Système International units (μmol/L), multiply by 88.4.

![Figure 2](image2.png) Bland-Altman plot for Radiometer ABL800 FLEX whole blood creatinine values compared with reference plasma creatinine values (difference between whole blood and plasma creatinine values vs mean of whole blood and plasma value). Values are given in conventional units. To convert to Système International units (μmol/L), multiply by 88.4.

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<th>Table 1</th>
<th>Clinical Concordance Between Whole Blood and Plasma eGFR*</th>
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<td>Radiometer</td>
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<td>Plasma eGFR &lt;60 (n = 68)</td>
<td>55 (81)</td>
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<tr>
<td>Plasma eGFR ≥60 (n = 198)</td>
<td>192 (97)</td>
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<tr>
<td>Overall concordance (n = 266)</td>
<td>247 (93)</td>
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* eGFR, estimated glomerular filtration rate. Data are given as number (percentage).
Devices that overestimate plasma creatinine levels will have increased sensitivity for the detection of plasma eGFR less than 60 mL/min/1.73 m² at the expense of specificity (Table 1).

The StatSensor demonstrated lowered sensitivity for detection of plasma samples with eGFR less than 60 mL/min/1.73 m² when the offset was not used, as a result of systematic underestimation of plasma creatinine levels. Use of the offset (Table 1) improved sensitivity for detection of eGFR less than 60 mL/min/1.73 m². All 28 patients with plasma eGFR less than 60 mL/min/1.73 m² misclassified by the StatSensor with offset values (reported as ≥60 mL/min/1.73 m²) had plasma eGFR more than 43 mL/min/1.73 m² and plasma creatinine levels of 1.5 mg/dL (133 μmol/L) or less.

Differences in sensitivity (for detection of plasma eGFR <60 mL/min/1.73 m²) between whole blood devices were statistically significant (P < .02) for all comparisons. Differences in specificity were statistically significant for all comparisons except StatSensor offset vs i-STAT (P = .28). Differences in overall concordance between devices were statistically significant except for borderline significance of the Radiometer vs i-STAT (P = .06) and no significant difference between the StatSensor and the StatSensor offset (P = .28).

**Discussion**

Chronic renal disease is a major health problem in the United States. Estimation of the glomerular filtration rate from serum creatinine levels is particularly useful in clinical situations requiring rapid decision making based on renal function, such as the decision to administer radiographic contrast media before radiographic or cardiology procedures. The availability of a rapid serum creatinine assay may allow differential treatment decisions to be made for patients at risk of developing contrast-induced nephropathy. However, significant concern remains about the impact of analytic bias on eGFR. Clinical studies are needed to demonstrate whether whole blood creatinine assays are accurate enough to provide reliable estimates of the glomerular filtration rate at the point of care.

At least 2 previous studies have found that the i-STAT whole blood creatinine assay overestimates plasma creatinine levels as measured by 2 different laboratory methods. One of those studies compared concordance of i-STAT whole blood eGFR with plasma eGFR calculated from a Roche IDMS-calibrated creatinine method on a small group of patients (n = 50). This study found that sensitivity for detecting plasma eGFR less than 60 mL/min/1.73 m² was 100%, whereas specificity was only 85%. These numbers are very similar to the 96% sensitivity (≥60 mL/min/1.73 m²) and 87% specificity (≥60 mL/min/1.73 m²) observed in our larger study. Thus, multiple studies have now demonstrated that systematic overestimation of plasma creatinine levels on the i-STAT leads to very sensitive detection of plasma eGFR less than 60 mL/min/1.73 m² at the expense of specificity. The usefulness of i-STAT screening may, therefore, depend on the adverse consequences of misclassifying patients with plasma eGFR 60 mL/min/1.73 m² or more, which likely differ by procedure and practice environment.

No similar study has been done using the Radiometer ABL800 FLEX, a recently available whole blood creatinine assay. The Radiometer analyzer is the only whole blood creatinine method with calibration traceability to an IDMS standard and has previously demonstrated excellent agreement with laboratory creatinine assays using IDMS calibration. We found that of the 3 devices, whole blood creatinine levels on the Radiometer correlated best with plasma creatinine levels on the Roche Cobas Integra 400. The Radiometer had a small negative bias compared with plasma creatinine, resulting in decreased sensitivity for the detection of plasma eGFR less than 60 mL/min/1.73 m² compared with the i-STAT method that overestimated plasma creatinine levels. However, specificity was improved on the Radiometer (compared with i-STAT), and there was a trend toward improved overall concordance.

Although an eGFR less than 60 mL/min/1.73 m² is clearly a risk factor for contrast-induced nephropathy, the risk of CIN increases in a graded manner as the eGFR decreases from 60 to 20 mL/min/1.73 m². One large study of CIN risk factors found that a serum creatinine level of more than 1.5 mg/dL (133 μmol/L) was a very strong risk factor for development of CIN. Use of the eGFR instead of the serum creatinine level was also effective in identifying at-risk patients. However, patients with eGFR values between 40 and 60 mL/min/1.73 m² were determined to be at lower risk for CIN compared with patients with lower eGFR or serum creatinine levels of more than 1.5 mg/dL (133 μmol/L). In fact, 1 large randomized trial that evaluated treatment options to prevent CIN enrolled only patients with serum creatinine levels of 2.0 mg/dL (177 μmol/L) or more or eGFR less than 40 mL/min/1.73 m². Thus, it is clear that patients with eGFR between 40 and 60 mL/min/1.73 m² and plasma or serum creatinine levels of 1.5 mg/dL (133 μmol/L) or less make up a relatively lower risk population of patients with renal impairment.

In our study, all 13 patients with plasma eGFR less than 60 mL/min/1.73 m² who were misclassified by the Radiometer whole blood assay had plasma eGFR more than 45 mL/min/1.73 m² and plasma creatinine values of 1.5 mg/dL (133 μmol/L) or less. Although other clinical risk factors for CIN were not identified in this study, the 13 misclassified patients with moderate renal insufficiency likely had relatively low risk of CIN. All patients with plasma eGFR 45 mL/min/1.73 m² or less or plasma creatinine levels of more than 1.5 mg/dL (133 μmol/L) were correctly identified by the Radiometer whole blood assay.
Institutions that use an IDMS-calibrated laboratory creatinine assay may find that the Radiometer method is suitable for whole blood eGFR determination before making contrast dosing decisions. Practices that want to maximize the sensitivity for detection of plasma eGFR less than 60 mL/min/1.73 m² might choose a device that slightly overestimates (as opposed to underestimates) plasma creatinine values. In weighing the use of the Radiometer device compared with the i-STAT, the consequences of misclassifying a few patients with plasma eGFR between 45 and 60 mL/min/1.73 m² and plasma creatinine levels of 1.5 mg/dL (133 μmol/L) or less (on the Radiometer) will need to be compared with the consequences of reducing contrast dose or changing treatment plans based on misclassification of patients with plasma eGFR 60 mL/min/1.73 m² or more (on the i-STAT). In our practice, patients with eGFR less than 30 mL/min/1.73 m² will have contrast withheld, limiting the quality of the diagnostic image and potentially preventing a critical diagnosis from being made. Methods that systematically overestimate serum and plasma creatinine values may be less optimal for use in radiology practices that see many patients with severe renal disease because the frequency of falsely withholding contrast would be expected to increase. However, our study did not allow for direct comparison of methods in this patient population owing to small numbers of patients with eGFR less than 30 mL/min/1.73 m².

Institutions that use an IDMS-calibrated serum or plasma laboratory method and whole blood creatinine measurements on the same population of patients will need to determine the amount of confusion and inefficiency that might be caused by discordant eGFR values. For example, if both laboratory and whole blood eGFR results will remain in the medical record, will physicians who view these results after the radiologic procedure understand the reason for discrepancies in eGFR classification? Physicians who view whole blood creatinine and eGFR results after the radiology procedure will most likely consider the creatinine value and eGFR before considering follow-up actions. For this reason, whole blood methods that minimize absolute bias (as opposed to just eGFR concordance) may be more efficient for the medical institution as a whole. These practice issues may determine the relative importance of sensitivity, specificity, and overall concordance for a given hospital or laboratory.

The StatSensor, another new device for measurement of whole blood creatinine levels, demonstrated lower concordance with the plasma creatinine reference method. However, the StatSensor offers users the option of entering an offset to match StatSensor whole blood to local laboratory creatinine values. In theory, this offset feature could be used to optimize the sensitivity or the specificity for detection of plasma eGFR less than 60 mL/min/1.73 m². Similar to the Radiometer method, all patients with plasma eGFR less than 60 mL/min/1.73 m² misclassified by the StatSensor (with offset) fell into a relatively low-risk group for CIN (plasma eGFR >40 mL/min/1.73 m² and plasma creatinine level ≤1.5 mg/dL [133 μmol/L]). In addition, 1 study found that concordance between eGFR determined from whole blood and plasma creatinine values was better when capillary blood was used to dose the StatSensor compared with heparinized whole blood. This device may be better suited for use with capillary whole blood.

The cost-benefit of using whole blood creatinine assays for risk stratification of patients before contrast administration will likely vary with practice volume and environment. In our practice, the whole blood method decreases turnaround time for creatinine results by approximately 20 minutes. Assuming average patient throughput for our practice and the average number of patients per day who might wait for creatinine results before CT, we estimate that reducing turnaround time by 20 minutes would allow for 1 to 3 additional patients to have CT scans performed per day. Reagent cost is increased by $1 to $5 per test using whole blood creatinine methods. Given our current volume of stat creatinine testing, this would increase laboratory costs by approximately $650 to $3,250 per month. However, this would be offset by an expected revenue increase of approximately $1,000 to $3,000 per day, assuming that decreased creatinine turnaround time resulted in 1 to 3 additional patients receiving CT scans. Thus, use of whole blood creatinine assays may be appropriate in institutions with a high volume of CT scans or procedures requiring contrast administration.

Limitations

There were few patients with severe (plasma eGFR <30 mL/min/1.73 m²) renal insufficiency in our study population, and this likely adversely affected the observed sensitivity of the Radiometer and StatSensor methods that underestimated plasma creatinine values. The patient population was also older (mean age, 68 years), and this may limit the usefulness of eGFR estimation regardless of method. In addition, clinical risk factors for CIN such as diabetes or history of previous renal disease or transplantation were not known for our study population; thus, the clinical risk of CIN could not be fully evaluated for each patient in the study.

Conclusion

We compared the i-STAT, StatSensor, and Radiometer ABL800 FLEX whole blood creatinine assays with an IDMS-calibrated plasma creatinine method. The Radiometer device demonstrated the best overall correlation to plasma creatinine levels and best clinical concordance when creatinine values were used to calculate eGFR. The i-STAT
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systematically overestimated plasma creatinine levels and, thus, has improved sensitivity but decreased specificity for determination of eGFR less than 60 mL/min/1.73 m² compared with the Radiometer. The StatSensor significantly underestimated plasma creatinine levels but offers users the ability to enter a slope and an intercept offset to match whole blood to plasma creatinine levels, and this feature significantly improved sensitivity for the detection of plasma eGFR less than 60 mL/min/1.73 m².

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