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Original Article

Comparison of estimated glomerular filtration rate equations at the time of hemodialysis initiation

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Abstract

Background: Estimated glomerular filtration rate (eGFR) is one of the most important guidelines in deciding the optimal timing of dialysis initiation. In the present study, we calculated the eGFR at the time of hemodialysis (HD) initiation using 5 commonly used equations to relate them with clinical and laboratory characteristics of the patients and to evaluate which of these equations best define the eGFR at HD initiation.

Methods: We retrospectively analyzed 409 end-stage renal disease patients who were newly started on HD treatment in our institution. The eGFR was calculated using the Cockcroft–Gault equation, the Cockcroft–Gault equation corrected for body surface area, the Modification of Diet in Renal Disease (MDRD) equation, the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation, and the Nankivell equation.

Results: The mean eGFRs at HD start were significantly different across the equations. The mean eGFR was 7.8 mL/min for the corrected Cockcroft–Gault equation, 7.7 mL/min for the Cockcroft–Gault equation, 6.2 mL/min/1.73 m^2 for the MDRD equation, and 5.6 mL/min/1.73 m^2 for the CKD-EPI equation. The corrected Cockcroft–Gault, the MDRD, and the CKD-EPI equations were well correlated with all CKD-specific complications including hypertension, anemia, hyperkalemia, metabolic acidosis, hypocalcemia, hyperphosphatemia, and hyperparathyroidism. The mean eGFR calculated by the corrected Cockcroft–Gault equation showed the lowest coefficient of variation among all the equations.

Conclusions: The eGFR at HD initiation are significantly different according to the used eGFR equations, and the corrected Cockcroft–Gault equation may be the best in defining the eGFR at HD initiation.

Introduction

Dialysis now offers life-sustaining treatment to approximately 2 million end-stage renal disease (ESRD) patients worldwide [1]. The guidelines across many regions in the world recommend the initiation of dialysis based on estimated glomerular filtration rate (eGFR). In fact, the guidelines of National Kidney Foundation Kidney Disease Outcomes

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Quality Initiative [2], European [3], Australian [4], and Canadian guidelines [5], recommend the initiation of dialysis when the eGFR is less than 10–15 mL/min. However, recent studies showed that the early dialysis initiation as recommended by these guidelines was not associated with an improvement in clinical outcomes, as compared to the late-start dialysis [6–9].

The Initiating Dialysis Early and Late (IDEAL) study is a prospective, multicenter, randomized, controlled trial to compare outcomes in patients starting dialysis with a higher versus lower eGFR, where the mean eGFR was 12.0 mL/min for the patients who started dialysis early and 9.8 mL/min for those who started dialysis late with the use of the corrected Cockcroft–Gault equation and 9.0 mL/min and 7.2 mL/min, respectively, with the use of the Modification of Diet in Renal Disease (MDRD) equation [6]. Interestingly, the differences between the early-start and the late-start groups (2.2 and 1.8 mL/min) were smaller than the differences created by the 2 equations within the group (3.0 and 2.6 mL/min), which indicates that the discrepancy of the mean eGFR between the 2 equations is too big for the equations to be used interchangeably.

In the present study, we calculated the eGFR at the time of hemodialysis (HD) initiation using 5 commonly used equations including the Cockcroft–Gault equation, the Cockcroft–Gault equation corrected for body surface area, the MDRD equation, the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation, and the Nankivell equation to relate them with clinical and laboratory characteristics of the patients and to evaluate which of these equations best define the eGFR at HD initiation.

Methods

Patients

We retrospectively analyzed ESRD patients who were newly started on HD between January 2010 and December 2012 in our institution. Patients were included if they were 18 years or older and started HD for the first time. Data regarding clinical and demographic characteristics including age, gender, height, weight, systolic and diastolic blood pressures, causes of ESRD, and comorbidities including diabetes mellitus (DM), hypertension, cardiovascular disease (CVD), and congestive heart failure (CHF) were collected from the medical records. DM was defined based on the presence of documented or self-reported history of diabetes or diabetic retinopathy or the presence of diabetic medications in patients' prescription records. Hypertension was defined in the same way as in DM. This study was approved by the Institutional Review Board of our institution.

Laboratory data

Blood urea nitrogen, creatinine (Cr), bone mineral markers (intact parathyroid hormone, phosphorus, and total calcium), a nutritional marker (albumin), metabolic acidosis markers (bicarbonate), and anemia markers (hemoglobin) were recorded. All laboratory data except intact parathyroid hormone levels were obtained within 1 day before the start of HD. Intact parathyroid hormone levels were obtained within 3 months before the start of HD or within 3 days after the start of HD.

Estimated glomerular filtration rate

For eGFR, we used 5 equations as follows: Cockcroft–Gault equation [10], [140 − age (years)] × [weight (kg)] × (0.85 if female)/[72 × serum Cr (sCr, mg/dL)]; Cockcroft–Gault equation corrected for body surface area, [140 − age (years)] × [weight (kg)] × (0.85 if female)/[72 × sCr (mg/dL)] × 1.73/body surface area (m^2); MDRD equation [11], 186.3 × [sCr (mg/dL)]$^{-1.154}$ × [age (years)]$^{-0.203}$ × (0.742 if female); CKD-EPI equation [12], 141 × min [Scr (mg/dL)/κ,1]$^{\alpha}$ × max [Scr (mg/dL)/κ,1]$^{-1.209}$ × 0.993$^{\text{age (years)}}$ × 1.018 (if female) × 1.159 (if black), where κ is 0.7 for females and 0.9 for males, α is −0.329 for females and −0.411 for males, min indicates the minimum of Scr/κ or 1, and max indicates the maximum of Scr/κ or 1; Nankivell equation [13], [6.7/sCr (mmol/L)] + [weight (kg)/4] − [serum urea (mmol/L)/2] − [100/height $(m)^2$] + (35 if males and 25 if females).

Statistical analysis

Continuous variables are described as means with standard deviation and categorical variables as proportions. Differences between the subgroups were assessed using chi-square tests for categorical variables and Student's *t* tests for continuous variables. The coefficient of variation (CV) was calculated as the percent ratio of the standard deviation to the mean. Correlations between variables were assessed by Pearson's correlation tests. Values of $P < 0.05$ were considered statistically significant. The analyses were performed using the Statistical Package for Social Sciences (SPSS for Windows 18.0, SPSS Inc., Chicago, IL, USA).

Results

Between January 2010 and December 2012, 1,369 patients who were new to our HD unit were reviewed, and of these, 660 patients were excluded because they had started HD previously in other centers. Other excluded patients were 249 who received HD for acute kidney injury, 17 who received pre-emptive HD for kidney transplantation, 11 who returned to HD after renal allograft failure, and 23 who switched to HD from peritoneal dialysis. Finally, 409 patients who started maintenance HD for ESRD were included in the present analysis. Table 1 summarized the patients' demographics and the causes of ESRD. The mean age was 58 years, and 52.6% of the patients were men. Comorbidities were common, particularly hypertension (81.9%) and DM (52.8%). The most common causes of ESRD were diabetic nephropathy (48.7%), followed by biopsy-proven glomerulonephritis (11.7%). The mean eGFR at the start of HD was significantly different across the different equations (Table 2). The highest mean eGFR was derived from the corrected Cockcroft–Gault equation (7.8 ± 3.6 mL/min/1.73 m^2) followed by the Cockcroft–Gault (7.7 ± 3.8 mL/min), MDRD (6.2 ± 3.4 mL/min/1.73 m^2), CKD-EPI (5.6 ± 3.2 mL/min/1.73 m^2), and finally the Nankivell equation (0.10 ± 12.74 mL/min/1.73 m^2; Table 2). CV of each eGFR was used to evaluate the extent of variability in relation to the mean eGFR. The results showed that the CV of the corrected Cockcroft–Gault equation (46.0%) was the smallest among the included equations, whereas the Nankivell equation showed the biggest CV (127.4%) despite its lowest eGFR value (Table 2).