ELSEVIER CrossMark

Performance of the MDRD, CKD-EPI, and Cockcroft-Gault Formulas in Relation to Nutritional Status in Stable Renal Transplant Recipients

Ł. Czyżewski[a,*], J. Wyzgał[a], E. Czyżewska[b], A. Kurowski[c], J. Sierdziński[d], A. Łabuś[a], Z. Truszewski[e], and Ł. Szarpak[e]

[a]Department of Nephrology Nursing, Medical University of Warsaw, Warsaw, Poland; [b]Department of Laboratory Diagnostics, Medical University of Warsaw, Warsaw, Poland; [c]Department of Anesthesiology, Cardinal Wyszynski National Institute of Cardiology, Warsaw, Poland; [d]Division of Medical Informatics and Telemedicine, Medical University of Warsaw, Warsaw, Poland; and [e]Department of Emergency Medicine, Medical University of Warsaw, Warsaw, Poland

ABSTRACT

Background. Monitoring of the function of the implanted kidney in renal transplant recipients (RTRs) is one of the superior elements of adequate therapeutic actions. The aim of this study was to assess the conventional and unconventional factors affecting the estimated glomerular filtration rate (eGFR) with the Modification of Diet in Renal Disease (MDRD), Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI), and Cockcroft-Gault (C-G) formulas among the RTRs.

Methods. The study included 144 RTRs (mean age 52 years). Clinical and laboratory data were analyzed; eGFR was calculated with MDRD, CKD-EPI, and C-G formulas. We compared the results with MDRD as a reference calculating the percentage of reclassifications of chronic kidney disease (CKD) stages. Nutritional status was assessed with a body composition analyzer, Tanita BC 418.

Results. Multivariable linear regression analysis with MDRD and CKD-EPI formula as a dependent variable retained the following independent predictors: hemoglobin (Hb) (B = .365; *P* = .000), and red blood cell distribution width (RDW) (B = −.191; *P* = .024). Analysis of variance showed the existence of statistically significant differences (all *P* for trend <.05) between the CKD-EPI, MDRD, and C-G equations within the total scope of eGFR results (51.2 ± 21.2 vs 47.5 ± 18.7 vs 55.6 ± 20.6, respectively) as well as in quartiles of eGFR.

Conclusions. Our data indicate that (1) with a value of eGFR >60 mL/min/1.73 m^2, the MDRD formula shows values that are on average 11% lower than in the CKD-EPI and C-G formulas; (2) with a value of eGFR <60 mL/min/1.73 m^2, the MDRD and CKD-EPI formulas do not show statistically significant differences.

MONITORING OF THE FUNCTION of the implanted kidney in renal transplant recipients (RTRs) is one of the superior elements of adequate therapeutic action. It should be emphasized that apart from the treatment and prevention of the development of chronic nephropathy of the implant, it is equally important to evaluate and monitor for acute kidney disease. According to the current KDIGO 2013 recommendations, the commonly applied formula, Modification of Diet in Renal Disease (MDRD), used to calculate estimated GFR (eGFR) should be replaced with the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) formula [1]. The Cockcroft-Gault (C-G) formula, in spite of its limitations, is still used in many clinical centers. The aim of this study was to assess the conventional (body mass, sex, age) and unconventional (waist circumference, body mass index [BMI], size of fat and muscle) factors affecting the eGFR value with the MDRD, CKD-EPI, and C-G equations among the RTRs.

*Address correspondence to Lukasz Czyżewski, Department of Nephrology Nursing, Medical University of Warsaw, Oczki 8 Str., 02-007 Warsaw, Poland. E-mail: czyzewski_lukasz@wp.pl

0041-1345/16
http://dx.doi.org/10.1016/j.transproceed.2016.01.083

SUBJECTS AND METHODS

An observational, cross-sectional, cohort, one-center study was carried out between April 2015 and September 2015. Qualified for participation in the study were 144 (mean age 52 years) Caucasian patients consecutively admitted to the Nephrology and Transplantation Outpatient Clinic of the Child Jesus Teaching Hospital in Warsaw. The patients were 6 months to 25 years after kidney transplantation (KTx). The patients qualified for the study were informed through oral or written instruction about the principles, aims, and benefits resulting from the study and expressed written consent to their participation in it. The criteria for inclusion in the study included age $\geq$18 years, time elapsed from kidney implantation $\geq$6 months to exclude the effect of immunosuppression, and stable function of the allograft, ie, creatinine clearance unchanged by more than 5 mL/min/1.73 m^2 for at least 3 months. Excluded from the study were patients with active infections, combined organ transplants, metal valves, stents, metal sutures, or metal prostheses.

The protocol of the study was approved by the Local Research Ethics Committee at the Medical University of Warsaw (approval no. KB/70/2015) and registered in the Clinical Trials Register (www.clinicaltrials.gov, identifier NCT02443363). The investigation conformed to the principles outlined in the Declaration of Helsinki. Bioelectrical impedance analysis (BIA) measurements were carried out during the patient's routine visits to the nephrology and transplantation clinic. All BIA measurements were made by one trained researcher from 08:00 to 10:00 AM, before breakfast. Body mass, height, waist circumference, and body mass index (BMI) were assessed. BMI was calculated as body weight (kg) divided by the square of body height (m). Abdominal obesity was defined as waist circumference of 102 cm in men and 88 cm in women [2]. The laboratory findings (creatinine concentration [S_{Cr}], C-reactive protein [CRP], hemoglobin A1C [HB1aC], lipidoprotein profile, hemoglobin [Hb], red blood cell distribution width [RDW], vitamin D) were obtained from the medical records of the patient. Because the MDRD formula is the formula preferred and is commonly applied in analytical laboratories in Poland, it was used as a method of reference for the comparative analyses performed with the application of the CKD-EPI and C-G formulas.

Calculation Formula

All measurements of S_{cr} were performed in one laboratory using the Jaffé method (Roche Diagnostics), and using specific diagnostic methods for calibration according to international reference standards. The isotope dilution mass spectrometry method was used as the reference method. Glomerular filtration rate was estimated using the following 3 equations: CKD-EPI [3]: for women with $S_{cr} \leq 0.7$, $(S_{cr}/0.7)^{-0.329} \times (0.993)^{age}$ ($\times$ 166 if black, $\times$ 144 if white or other); for women with $S_{cr} >0.7$, $(S_{cr}/0.7)^{-1.209} \times (0.993)^{age}$ ($\times$ 166 if black, $\times$ 144 if white or other); for men with $S_{cr} \leq 0.9$; $(S_{cr}/0.9)^{-0.411} \times (0.993)^{age}$ ($\times$ 163 if black, $\times$ 141 if white or other); for men with $S_{cr} >0.9$, $(S_{cr}/0.9)^{-1.209} \times (0.993)^{age}$ ($\times$ 166 if black, $\times$ 144 if white or other); 4-variable MDRD study equation [4]: (GFR = 175 $\times$ S_{cr} $^{-1.154}$ $\times$ $age^{-0.203}$ $\times$ 1.21 [if black] $\times$ 0.742 [if female]); and the C-G equation [5] adjusted for body surface area (C_{cr} = [140 − age] $\times$ weight $\times$ 0.85 [if female] $\times$ 1.73/72 $\times$ standardized S_{cr} $\times$ body surface area [BSA]). After the performance of correction for the BSA, these equations, eGFR and C_{cr}, are expressed as mL/min per 1.73 m^2 of the body surface area. This was performed using estimated BSA according to Du Bois and Du Bois [6]: BSA = weight $[kg]^{0.425}$ $\times$ height $[m]^{0.7250}$ $\times$ 20247.

Body Composition and Volume Measurement

In our study we applied the body composition analyzer Tanita BC 418 (Tanita Corporation, Tokyo, Japan), a technique based on the BIA measurement, with the use of a single 50-kHz current frequency (single frequency BIA-SF-BIA), 8-contact electrode system. The analyzer measured total body water (%) (TBW), total volume of adipose tissue in the organism as a whole against body mass expressed in percent (fat%) and within the abdominal cavity (ViscFat%). Visceral fat ratio was an indicator of basal metabolic rate (BMR in kcal).

Statistical Analysis

Results concerning quantitative variables were presented as average values $\pm$ standard deviation (SD). In the comparative characteristics of eGFR calculation methods of Bland-Altman analysis, one-way analysis of variance and post-hoc NIR test were used. In the multivariable linear regression analysis, the multivariable linear regression analysis of variance was applied. Statistica 12 software (StatSoft Inc., Tulsa, OK, USA) was used in the statistical analysis. The significance level was $P < .05$.

RESULTS

The present study included 144 RTRs with a mean age of 52 years, male gender rate of 61%, mean eGFR of 47.4 mL/min/1.73 m^2, mean fat (%) of 24%, mean ViscFat (%) of 23%, median time from transplantation of 5 years, and mean waist circumference of 101 cm; 77% (111 RTRs) had an eGFR <60 mL/min/1.73 m^2.

Univariate Comparison of Quartiles of eGFR According to CKD-EPI, MDRD, and C-G Equation

One-way analysis of variance showed the existence of statistically significant differences (all P for trend <.05) between the CKD-EPI, MDRD, and C-G equations within the total scope of eGFR results (51.2 $\pm$ 21.2 vs 47.5 $\pm$ 18.7 vs 55.6 $\pm$ 20.6, respectively) as well as in quartiles of eGFR: eGFR <30 mL/min/1.73 m^2 (23.1 $\pm$ 6.5 vs 22.1 $\pm$ 5.9 vs 29.2 $\pm$ 8.3, respectively); eGFR >30<60 mL/min/1.73 m^2 (47.8 $\pm$ 10.1 vs 44.5 $\pm$ 8.7 vs 53.4 $\pm$ 12.2, respectively); eGFR >60 mL/min/1.73 m^2 (80.8 $\pm$ 15.0 vs 72.0 $\pm$ 12.3 vs 80.6 $\pm$ 16.7, respectively) (Fig 1).

The Bland-Altman analysis carried out between the formulas MDRD and CKD-EPI produced a coefficient of 4.9, consistency of findings on the level of 95.1%, as well as a mean eGFR difference of 3.6 mL/min/1.73 m^2. In the case of the MDRD and C-G formulas, the coefficient amounted to 7, the consistency of the results was on the level of 93%, and mean difference was 8 mL/min/1.73 m^2. In the case of the CKD-EPI and C-G formulas, the coefficient reached 12, the consistency of results was on the level of 88%, and mean difference was 4.4 mL/min/1.73 m^2.

Multivariable Linear Regression Analysis With eGFR: CKD-EPI Equation

The independent predictors retained in the final regression model were Hb (B = .365; P = .000), and RDW (B = −.191; P = .024). The remaining factors were eliminated.