Application of modified glomerular filtration rate estimation equations in Chinese diabetic patients with chronic kidney diseases

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Abstract: Objective: To evaluate the applicability of modified formulas based on plasma creatinine levels in Chinese diabetic patients with chronic kidney diseases (CKD). **Methods:** A total of 294 diabetic patients were investigated. Glomerular filtration rate (GFR) was estimated with the Ruijin equation, Cockeroft-Gauh(CG)and Modification of Diet in Renal Disease (MDRD) formula.The accuracy of estimated GFR was compared with 99mTc-DTPA-GFR(sGFR). **Results:** Bland-Altman analysis demonstrated that the Ruijin equation was more consistent with sGFR than the other equations. However , all the equations were not well consistent with sGFR. The analysis showed that the slope of the Ruijin equation was closer to the identical line and indicated that the bias of Ruijin equation was lowest.The 15%, 30% and 50% accuracies of the Ruijin equation was higher than those of the other equations, the 30% accuracy of Ruijin equations was more than 70%. There Was no significant difference between poorly-controlled group and well-controlled group in three equations. **Conclusions:** Ruijin equation is more applicable in Chinese diabetic and CKD patients.

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1. Introduction

The glomerular filtration rate (GFR) is an important indicator for clinical evaluation of renal function. ADA and other guidelines recommend Cockcroft Gault (GC) formula and modification of diet in renal disease (MDRD) formula to estimate GFR. Recently, eGFR project collaborative group (Chines eGFR investigation Collabaration 2006; Ma et al., 2006) and Ruijin hospital(Shi et al.,2006) developed new GFR assessment equation based on the Chinese population, respectively. In this study, we compared the eGFR and sGFR measured by ^{99m}Tc-DTPA, and evaluated the applicability of the above equation in our diabetic patients.

2. Objects and methods

2.1 Objects

294 cases of diabetes were chosen from March, 2008 to November, 2009 in our hospital, including 199 male and 95 female, the age was (57.28±13.95) years old, in which type 1 diabetes were 16 cases, and type 2 diabetes were 278 cases. The diagnosis of diabetes accord with WHO standard proposed in 1998. All patients were excluded from diabetic ketoacidosis, hyperosmolar nonketotic coma, urinary tract infections, serious heart and liver dysfunction, malignant tumors, and rheumatic diseases, etc.

2.2 Research methods

All patients underwent radionuclide renal dynamic imaging through projectile intravenous injection of ^{99m}Tc-DTPA (Siemens Signature e．Cam SPECT, Germany). We inputted the height and body mass of patients, calculated the sGFR with Gates method, and corrected the sGFR with body surface area (BSA).

We also detected the biochemical parameters in venous blood after patients fasting 12 h: hemoglobin (HGB), fasting plasma glucose (FPG), 2 hours postprandial glucose (2hPG), serum creatinine (Scr), triglyceride (TG) and total cholesterol (TC). All the indexes were measured with Hitachi 7600 automatic biochemistry analyzer. The Scr was measured with creatine oxidase method, and the hemoglobin Alc (HbAlc) was measured with high-pressure liquid chromatograpy. The albumin creatinine ratio (ACR) was detected with the first urine in the morning by immunoturbidimetric assay.

Cockcroft Gault formula: GFR=[(140-age)×weight (kg)]/[(72×Scr (mg/dl)], correction with BSA. MDRD formula: $186\times Scr\ (mg/dl)^{-1.154}\times age^{-0.203}\times 0.742$(female). Ruijin equation: $234.96\times (Scr)^{-0.926}\times (age)^{-0.280}\times 0.828$ (female). Scr conversion formula: 1 μmol/L=0.0113 mg/dl.

2.3 Statistically analysis

Data are expressed as mean±standard. The relationship between eGFR and sGFR is analyzed by Spearman. The consistency limits of eGFR and sGFR is calculated with Bland-Altman plotting method.

Consistency limits=95%×(eGFR-sGFR). Deviation from the measured values=∣eGFR-sGFR∣/ sGFR×100%. We made regression analysis of the deviation and average of eGFR and sGFR. The regression line and X-axis slope mean the degree of equation deviate from sGFR, the greater the slope, the greater the deviation; the regression line and Y-axis intercept mean the accuracy of the equation, the wider the intercept, the worse accuracy the equation. 15%, 30% and 50% compliance rate are the estimated values of equation fall in the range of sGFR±15%, ±30% and ±50%. The accuracy of equations was analyzed by chi-square test. All data were analyzed with SPSS 13.0 and MedCal software.

3. Results

3.1 General applicability

The GFR and sGFR estimated by all equations showed a significant correlation. Bland-Altman analysis showed that the GFR and sGFR estimated by Ruijin equation were the best; linear regression analysis showed that the slope of GFR and X-axis calculated with Ruijin equation was smaller than that estimated with other equations, the intercept of regression line on Y-axis was also smaller with Ruijin equation; compared with MDRD equation, the Ruijin and CG equations have smaller deviation; and the percentage of deviation from measurement was also the smallest in Ruijin equation; the GFR 15%, 30% and 50% compliance rate were the highest in Ruijin equation, and the GFR 30% compliance rate was higher than 70% only in Ruijin equation. (The abscissa represents the average of estimated value and sGFR, the ordinate represents the deviation of estimated value and sGFR. The blue solid line represents the average of estimated value and sGFR difference value; the two coffee color dotted lines represent the upper and lower limits of 95% consistency limits) (Table 1).

Table 1. Overall performance of agreement ,differences and accuracy between eGFR and sGFR.

	CG equation	MDRD equation	Ruijin equation
correlation coefficient	0.70	0.70	0.72
sistency limits	-45.1～65.5	-39.6～72.8	-37.2～50.2
Slope between regression lineand and X axis(95%CL)	0.42(0.32,0.51）	0.44(0.34,0.52)	0.15(0.06,0.24)
Intercept between regression lineand and Y axis(95%CL）	-26.55 (-35.33,-17.76)	-23.24(-32.25,-14.23)	-6.52(-14.91,1.87)
deviation value(25%,75%)	5.23（-6.76,26.15）	14.51（-3.14,34.09）	5.84（-5.83,20.72）
Deviation measured value%（25%，75%）	21.87（8.53,38.42）	25.76（10.90,47.15）	17.42（16.83,32.29）
15%coincidence rate	0.377551	0.363946	0.44898
30%coincidence rate	0.64966	0.598639	0.710884
50%coincidence rate	0.823129	0.785714	0.901361

3.2 Applicability of different stages of renal function

In our study, the CKD one stage was 123 cases, CKD two stage was 113 cases, CKD three stage was 48 cases and CKD four-five stage was 10 cases. There was a little deviation between Ruijin equation and CG equation in CKD one stage, the percentage of deviation from measurement was smaller in Ruijin equation. All the GFR 15%, 30% and 50% compliance rate were higher in Ruijin and GC formula. In CKD two stage, there also was a little deviation between Ruijin equation and CG equation, and the percentage of deviation from measurement was smaller in Ruijin and GC equations, the GFR compliance rate was higher in Ruijin and GC equations. In CKD three stage, CG formula had smaller deviation compared to other equations, the percentage of deviation from measurement was smaller in Ruijin and GC equations, and the GFR compliance rate was higher in Ruijin and GC equations. In CKD four to five stage, there were lower deviation and the percentage of deviation from the measurement in Ruijin equation that that in other equations, and the GFR compliance rate was also higher in Ruijin equation (Fig 1).

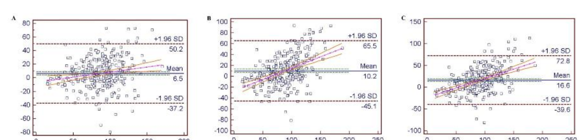

Fig 1. Bland-Altman plot of eGFR and sGFR. Solid line represents the mean of difference between methods; dashed lines represent 95% limits of agreement. parts of the figure represent the results as indicated on their axes.A.sGFR and eGFR- MDRD; B.sGFR and eGFR-CG;C.sGFR and eGFR-Ruijin equation.

4. Discussion

In this study, we used Bland-Altman analysis for conformance assessment, the results showed that the consistency of GFR and sGFR estimated by all equations were poor. The consistency limits of GFR and sGFR estimated by all equations exceeded the value of 60 ml·min-1 (1.73 m2)-1, in which, the consistency of GFR and sGFR estimated by Ruijin equation was the best one. The slope of GFR and X-axis and the intercept of regression line on Y-axis estimated by Ruijin equation were smaller than that estimated with other equations. In all equations, the GFR 15%, 30% and 50% compliance rate were the highest in Ruijin equation, and the GFR 30% compliance rate was more than 70% only in Ruijin equation according to the estimation of K/DOQI professional group(Wang and Wang 2003). In a word, evaluation of GFR with Ruijin equation which was developed based on Chinese population is more suitable for our diabetic patients with CKD.

99m Tc has features of shorter half-life, economic and practical and simple preparation, it has been widely applied in clinical practice(Schwartz and Furth 2007). The correlation of GFR and inulin clearance rate is good with ^{99m} Tc-DTPA; it is an accurate marker for GFR. American Society of Nuclear Medicine recommends a two-sample method as the reference standard to measure GFR, however, the blood need to be collected 2 h and 4 h after injection with two-sample method, so the patients need to wait a long time in the hospital; therefore, it is not convenient. There was a good correlation between ^{99m}Tc-DTPA method and two-sample method (P<0.01) (Fleming et al.,2004). It should be noted that some factors might affect our results. The picric acid and enzymatic methods are most common methods for determination of Scr; however, it has been proved that there was not a linear relationship between the measured values of two methods. In Ruijin equation, the Scr was determined by picric acid method, while the Scr was measured by enzymatic method in our study. There was deviation of Scr detected by different methods; therefore, it caused greater degree of deviation of GFR assessment based on Scr(Vickery et al., 2006). Moreover, different population and race also lead to deviation. Therefore, it needs further evaluation and validation of the applicability of the above equation in our diabetic population, and positive development of the assessment equation using the enzymatic method to detect Scr.

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