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Comparison of glomerular filtration rate measurements with the two-plasma sample technique using Tc-99m DTPA and other methods in donor candidates for renal transplantation

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Background/aim: Accurate measurement of glomerular filtration rate (GFR) in the evaluation of renal functions in potential kidney donors is associated with important outcomes for both the donor and recipient. We intended to determine the efficacy of various methods while estimating GFR in potential living kidney donors.

Materials and methods: Fifty-three potential kidney donors (31 females, 22 males; mean age: 50.1 years) were included in this study. GFR was estimated simultaneously using the following methods: Gates' method, Cockcroft–Gault (CG) and modification of diet in renal disease (MDRD) prediction equations, and the two-plasma sample (TPS) technique. Using TPS as the reference method, the estimations of GFR with the other methods were compared with that of TPS.

Results: The mean ± SD GFR was 86.43 ± 11.37 mL min^{-1} 1.73 m^{-2} with TPS. GFR values calculated using Gates' method and MDRD 1, MDRD 2, reexpressed MDRD, and CG prediction equations were 105.25 ± 16.12 mL min^{-1} 1.73 m^{-2}, 114.63 ± 32.51 mL min^{-1} 1.73 m^{-2}, 113.2 ± 35.23 mL min^{-1} 1.73 m^{-2}, 104.23 ± 23.12 mL min^{-1} 1.73 m^{-2}, and 99.35 ± 20.01 mL min^{-1} 1.73 m^{-2}, respectively. While there was a strong statistically significant correlation between the TPS and Gates' methods, moderate correlation was found between TPS and the MDRD 1, MDRD 2, and reexpressed MDRD prediction equations.

Conclusion: Our results indicated that the performance of Gates' method in total GFR estimation was better than the prediction equations in potential kidney donors.

Key words: Glomerular filtration rate, kidney donors, two-plasma sample

1. Introduction

Assessment of renal function and morphology in potential kidney donors is crucial (1). The renal function of the donor has important long-term consequences for both the donor and the recipient. Recipients have double the risk of graft loss when receiving a kidney from a live donor with a glomerular filtration rate (GFR) of <80 mL/min (2). Most transplant centers exclude potential donors with a creatinine clearance under 80 mL/min (3).

GFR is considered the best index of overall kidney function (4,5). GFR can be determined by measuring renal clearance of an intrinsic or extrinsic agent that is freely filtered by the glomeruli (6,7). Inulin clearance has been widely believed to be the gold standard for GFR studies, but it is relatively invasive and not easy to perform in everyday practice (8). Measurement of Tc-99m diethylenetriamine pentaacetic acid (Tc-99m DTPA) plasma clearance is used by many institutions for the determination of total GFR due to its simplicity and precision (9–12). It is also reported that there is a correlation between Tc-99m DTPA and inulin clearances when measuring GFR in clinical applications (13).

Measured Tc-99m DTPA serum clearance by multiple-plasma sample method (MPSM) is similar to inulin clearance; however, it is not practical to collect multiple plasma samples on a daily routine (14). To facilitate the procedure, Tc-99m DTPA clearance by the two-plasma sample (TPS) method was compared to MPSM and a significant correlation was reported (15). Serum creatinine is also a clinically useful marker for evaluating kidney functions. It is widely available and easy and inexpensive to use, but estimated GFR based on serum creatinine is likely

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to be inaccurate (16). To remedy this shortcoming, several formulas have been developed for precise calculation of GFR. The Cockcroft–Gault (CG) equation and the modification of diet in renal disease (MDRD) formulas have been offered in clinical guidelines for the calculation of GFR (17). The gamma camera Gates' method has also been utilized for the prediction of GFR, but the accuracy of this method is controversial (18,19).

Regarding TPS as a reference, we intended to determine the efficacy of Gates' method, MDRD methods, and CG formulas while estimating GFR in potential living kidney donors.

2. Materials and methods

2.1. Subjects

This study involved 53 potential kidney donors. Donors comprise 31 females and 22 males (age range: 25 to 70 years; median age: 51 years; mean age: 50.1 ± 10.6 years). We collected data on age, sex, weight, height, body surface area, blood urea nitrogen (BUN), serum creatinine (SCr), and serum albumin from each subject. The ethics committee of our university approved this study.

2.2. Measurement of glomerular filtration rate

We normalized all GFR values to 1.73 m^2 of body surface area.

2.2.1. Determination of GFR with Gates' method (18–20)

TPS and Gates methods were carried out simultaneously. DTPA was reconstituted in our department using a commercially available kit (TechneScan DTPA, Mallincrodt Medical B.V, Petten, the Netherlands). Radiochemical quality control was performed with thin-layer paper chromatography (ITLCTM, SG, Gelman Sciences, Ann Arbor, MI, USA) prior to each study. The fractions of Tc-99m (as free pertechnetate) and Tc-99m DTPA were determined by using methyl ethyl ketone and saline (0.9% NaCl) for unchelated hydrolyzed reduced Tc-99m as the eluent. The overall labeling efficiency was 96.4 ± 0.5% (mean ± SD) and Tc-99m DTPA was not used if the labeling efficiency was below 95%. After reconstitution and quality control of the radiopharmaceutical, two equal doses of 148 MBq of Tc-99m DTPA were prepared as the standard and the patient dose.

All patients were hydrated orally with 500 mL of water 30 min prior to injection. Oral fluid hydration was continued at 300–500 mL h^{-1} during the entire study until blood sampling at 240 min. The study was initiated simultaneously with the intravenous injection of 4 mCi (148 MBq) of Tc-99m DTPA. The patient was placed in the supine position and a dose of furosemide, with a maximum dose of 40 mg, was administered. Furosemide was used routinely in all patients. The dynamic image acquisition was performed for 30 min with a single-head gamma camera with a parallel-hole, low-energy, high-resolution collimator (GE-Starcam 4000 XR/T, St Albans, Hertfordshire, UK). Individual and total GFRs were readily obtained using Gates' method.

The GFR values were determined 2–3 min after injection of the Tc-99m DTPA. Renal and crescent-shaped background inferior regions of interest (ROIs) were drawn manually.

2.2.2. Determination of GFR with the TPS method (21,22)

After IV injection of Tc-99m DTPA, blood samples were taken from the contralateral arm into EDTA anticoagulant tubes and subjected immediately to centrifugation at 2000 rpm for 10 min. Plasma samples (1 mL) and the standards were counted in a gamma counter (Atomlab 950 LPC, Biodex Medical, Shirley, NY, USA) for 1 min. Blood samples were taken at 120 min and 240 min and used for the TPS.

GFR was calculated in mL min^{-1} as follows:

$$\text{GFR (ml/min)} = \frac{D\ln(P_1/P_2)}{T_2 - T_1}\exp\frac{(T_1\ln P_2) - (T_2\ln P_1)}{T_2 - T_1}$$

where D = dose activity (cpm); T_1 = 120 min; T_2 = 240 min; P_1 = activity at T_1; P_2 = activity at T_2; and P_1 and P_2 are in counts min^{-1} mL^{-1}.

2.2.3. Estimation of GFR by prediction equations (9,23)

MDRD 1:

$$\text{GFR} = 170 \times S_c^{-0.999} \times A^{-0.176} \times (\text{BUN})^{-0.176} \times (\text{Albumin})^{-0.318} (\times 0.762 \text{ for female patients})$$

MDRD 2:

$$\text{GFR} = 186 \times S_c^{-1.154} \times A^{-0.203} (\times 0.742 \text{ for female patients})$$

where S_c = serum creatinine (mg dL^{-1}) and A = age (in years).

Standardization of serum creatinine in donors:

This is used to standardize SCr measurements between different centers to minimize variability (24,25). It is also reported to calculate the reexpressed MDRD equation by standardizing the SCr values with the following formula:

Cleveland Clinic (CCF) standardized SCr = $0.906 \times (0.099 + 0.981 \times S_c)$

The new reexpressed MDRD equation used herein was as follows:

Reexpressed MDRD equation (24):

$$\text{GFR} = 175 \times \text{standardized } S_c^{-1.154} \times A^{-0.203}$$

($\times 0.742$ for female patients)

Cockcroft–Gault (26):

For man, the GFR im ml/min, is determined by: $\frac{(140 - A) \times w}{S_c \times 72}$ and for women, by: $\frac{(140 - A) \times w}{S_c \times 72 \times 0.85}$

Whenew=weight (kG)

2.3. Statistical analyses

We used Pearson's correlation coefficient for calibrating the association between TPS and other methods (Gates', creatinine clearance, and prediction equations). Statistical significance was defined as $P < 0.05$. The statistical analyses were performed using SPSS (SPSS Inc., Chicago, IL, USA). Bland–Altman analysis was performed to show the difference between TPS and the other methods by the mean of the two measures ± 2 SD.

3.Results

The mean age of the donors was 50.1 years. There were 31 (58%) women in the study group. The mean serum creatinine was 0.7 ± 0.2 mg dL^{-1} (range: 0.4–1.3 mg dL^{-1}). The mean GFR was 86.43 mL min^{-1} 1.73 m^{-2} (range: 35.99–122.35 mL min^{-1} 1.73 m^{-2}) in the TPS method. The mean ± SD, minimum, maximum, and median GFR values in the TPS method as well as the Gates', MDRD 1, MDRD 2, reexpressed MDRD, and CG methods are presented in Table 1.

Bland–Altman plots comparing TPS and the other methods are shown in Figures 1–5. Assessment of the performance of the Gates' method and other prediction equations are shown in Tables 1 and 2.

We found there was a strong correlation between the TPS and Gates' methods ($r = 0.76$, $P = 0.0001$). There was also a moderate correlation between TPS and MDRD 1 ($r = 0.47$, $P = 0.007$), MDRD 2 ($r = 0.38$, $P = 0.03$), and reexpressed MDRD ($r = 0.57$, $P = 0.002$). However, there was no significant correlation between the TPS and CG prediction equations. The correlation coefficient was $r = 0.26$, $P = 0.16$.

4. Discussion

Most transplant centers exclude potential donors with a creatinine clearance under 80 mL min^{-1} (3). Creatinine clearance has been used for many decades to estimate GFR (26). In estimating GFR, inulin is the gold standard method. There is a good correlation between Tc-99m DTPA and inulin clearance for GFR measurement, so it is commonly used to measure GFR (27,28). Tc-99m DTPA is excreted by the kidney and it binds to plasma proteins in the range of 5%–10%, which explains the underestimation of the GFR in comparison with inulin, which filters freely (29). Results MPSMs for the estimation of GFR after a single Tc-99m DTPA injection have been reported to be identical to inulin clearance (30). The multiple blood sampling method's correlation with the dual blood sampling method is also well documented. TPS was reported to be more precise in estimating GFR when compared to the single plasma sample method (31) and it was used in our study as the reference GFR (22).

Gamma camera-based clearance techniques for GFR estimation are easy and convenient for clinical use. Gates developed a method to estimate GFR, the Gates' method, in 1982 (18,32). This method is very simple and suitable for predicting the GFR of any differential renal function (33). However, there is also some debate whether the Gates' method is proper for determining the GFR (34,35). Aydın et al. reported that the Gates' method is weakly correlated with the TPS method (36). Nevertheless, Assadi et al. revealed that the Gates' method has a good correlation with the plasma sample method and was more precise than the CG method (37). Our results are consistent with previous results (35). We found a strong correlation between the TPS method and Gates' methods in our study.

There have been a number of formulas illustrating GFR calculations by using biometrical parameters such as height, weight, age, and sex, as well as calculations with serum creatinine levels and other biochemical variables. Among the commonly used equations are the CG and MDRD equations. Whether these equations precisely estimate the GFR or not has been disputed (38). While both formulas have a lower accuracy in high GFR populations, GFR predictions are less accurate in predicting GFR values in healthy populations (39). The CG equation is proclaimed to be better than the MDRD equation in the prediction of GFR (40,41), though others have noted that MDRD equations were better when compared to the CG equation in kidney donors (26,27,30). Issa et al. showed that the MDRD and reexpressed MDRD equations

Table 1. Assessment of the Gates's method and other prediction equations.

Method	Mean	SD	Minimum	Maximum	Median	Median absolute ifference (mL min^{-1} 1.73 m^{-2})	Mean percentage error
Gates	105.25	16.12	76.28	138.63	102.4	11.2	35.2 ± 16.2
MDRD1	114.63	32.51	66.22	196.24	111.24	20.3	46.6 ± 39.3
MDRD2	113.2	35.23	59.33	20287	109.82	18.1	45.5 ± 41.6
Reexpressed MDRD	104.23	23.12	67.75	152.74	102.13	12.9	34.6 ± 26.3
CG	99.35	20.01	62.25	148.23	98.24	3.7	24.6 ± 16..3

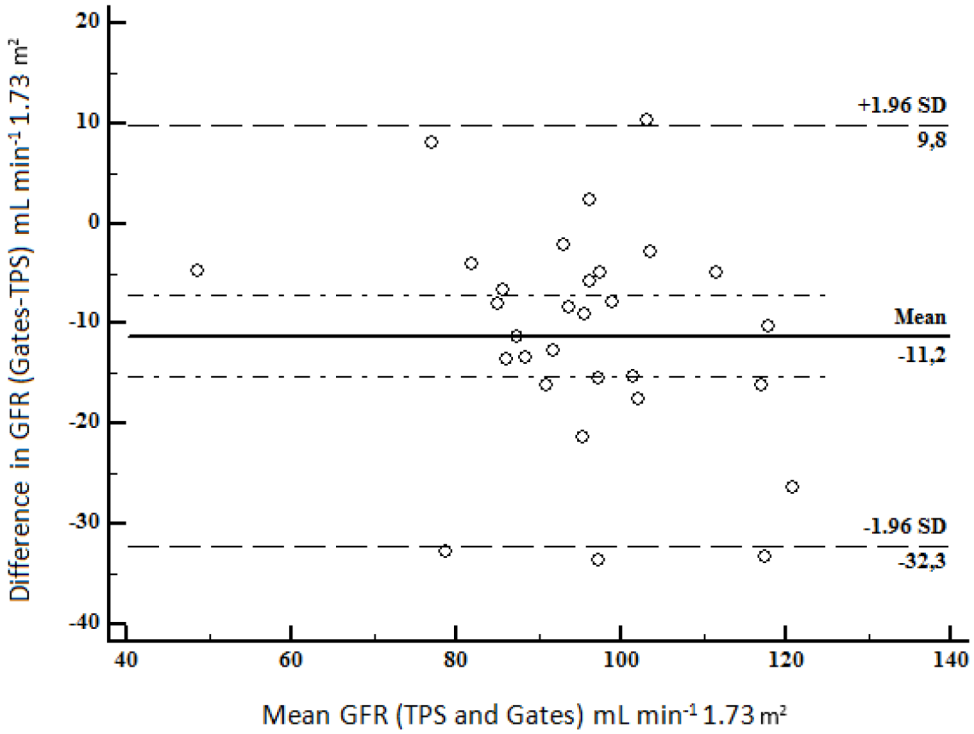

Figure 1. Bland–Altman plot of two-plasma sample method versus gamma-camera Gates' method.

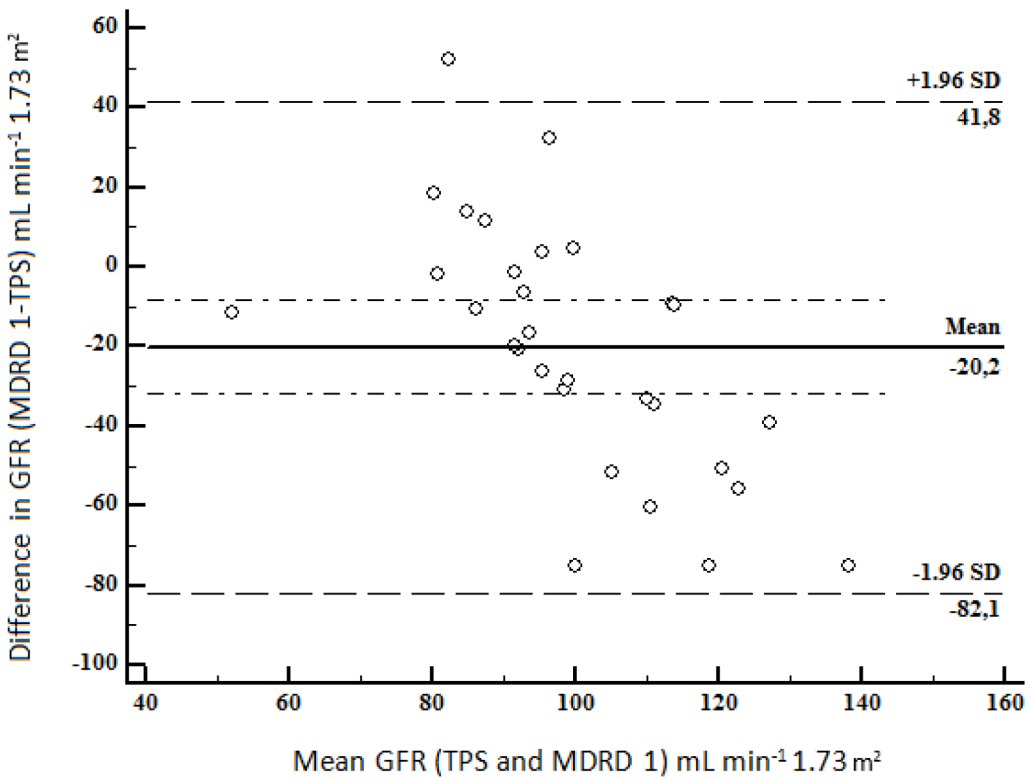

Figure 2. Bland–Altman plot of two-plasma sample method versus MDRD 1.

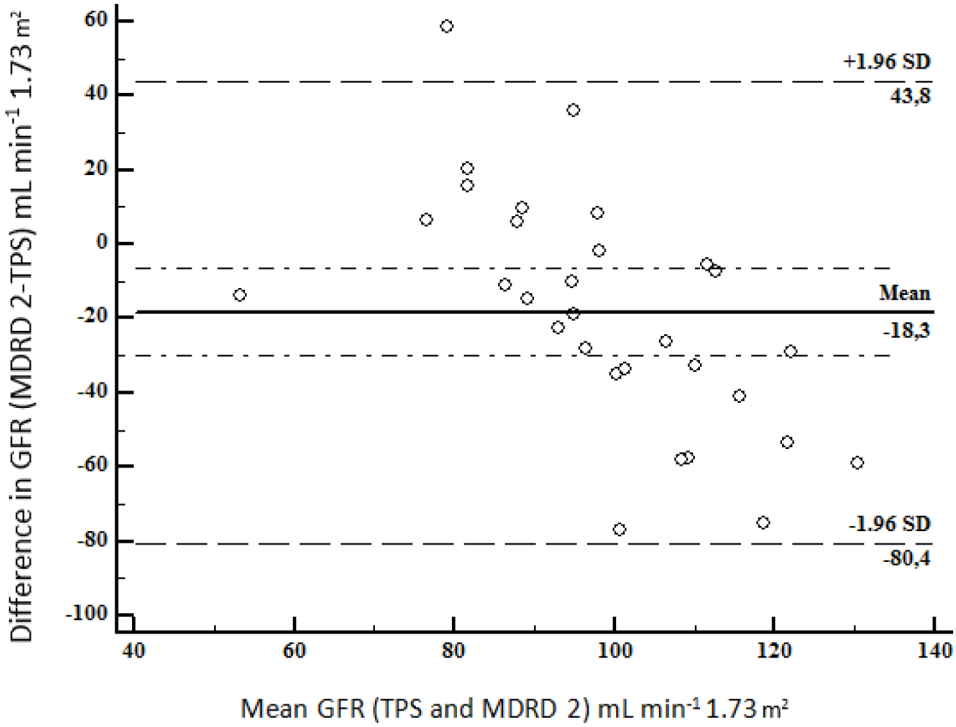

Figure 3. Bland–Altman plot of two-plasma sample method versus MDRD 2.

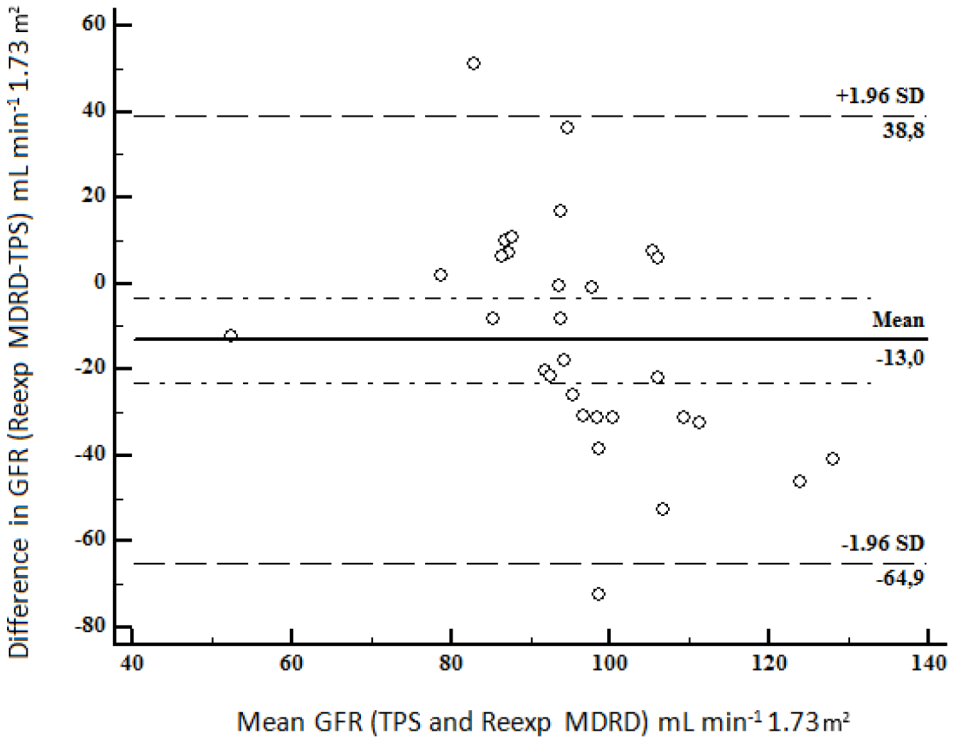

Figure 4. Bland–Altman plot of two-plasma sample method versus Reexp MDRD.

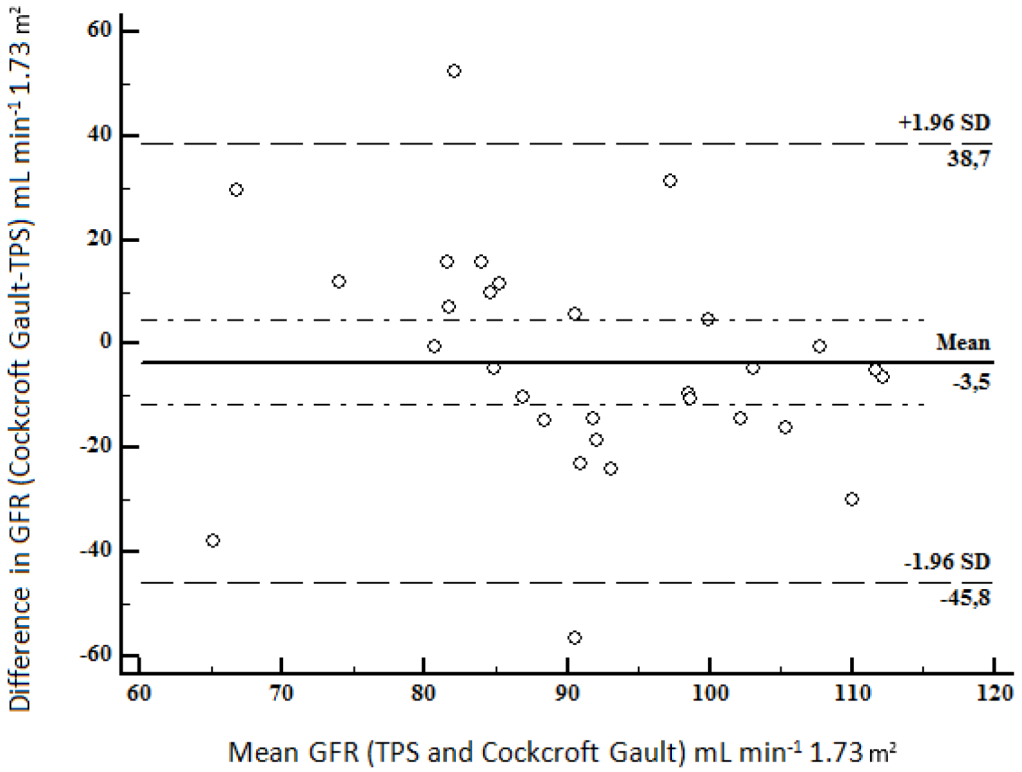

Figure 5. Bland–Altman plot of two-plasma sample method versus Cockcroft–Gault.

Table 2. The comparison and regression analysis of GFR measurement methods.

Method	R	R^2	P
Gates	0.76	0.58	0.0001
MDRD 1	0.47	0.22	0.007
MDRD 2	0.38	0.14	0.03
Reexpressed MDRD	0.57	0.32	0.002
CG	0.26	0,07	0.16

underestimated GFR (22). The correlation among the TPS and MDRD 1, MDRD 2, and reexpressed MDRD prediction equations were moderate in our study. There was no statistically significant correlation between TPS and CG prediction equations.

We acknowledge some limitations. First, very few individuals were included. Second, these analyses were performed with a small sample size with wide variability in clinical and laboratory parameters. Third, SCr, BUN, and albumin measurements were not performed at the same time in the same laboratory.

In conclusion, the present study has investigated several methods and compared the results with the TPS considered as the reference. Among them, our results demonstrate that Gates' method can reflect GFR more accurately than the other methods in potential kidney donors. Further studies with large numbers of donor are required to derive an improved prediction equation for estimating GFR in donor populations.

References

1. Kasiske BL, Ravenscraft M, Ramos EL, Gaston RS, Bia MJ, Danovitch GM. The evaluation of living renal transplant donors: clinical practice guidelines. J Am Soc Nephr 1996; 7: 2288-2313.
2. Norden G, Lennerling A, Nyberg G. Low absolute glomerular fi ltration rate in the living kidney donor: a risk factor for graft loss. Transplantation 2000; 70: 1360-1362.
3. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron 1976; 16: 31-41.
4. Levey AS, Bosch JP, Lewis JB, Greene T, Rogers N, Roth D. A more accurate method to estimate glomerular filtration rate from serum creatinine: a new prediction equation. Ann Intern Med 1999; 130: 461-470.
5. Parıldar Z, Gülter C, Habif S, Mutaf I, Turgan N, Özmen D, Bayındır O. Age and gender associated changes in cystatin C and 2-microglobulin. Turk J Med Sci 2002; 32: 317-321.
6. Imai E, Horio M, Nitta K, Yamagata K, Iseki K, Hara S, Ura N, Kiyohara Y, Hirakata H, Watanabe T et al. Estimation of glomerular filtration rate by the MDRD equation modifies for Japanese patients with chronic kidney disease. Clin Exp Nephrol 2007; 11: 41-50.
7. Balachandran T. Comparative evaluation of quantitative GFR measured by isotopic and non-isotopic methods. Clin Nucl Med 1981; 6: 150-153.
8. Peters AM, Glass DM, Bird NJ. Extracellular fluid volume and glomerular filtration rate: their relation and variabilities in patients with renal disease and healthy individuals. Nucl Med Commun 2011; 32: 649-653.
9. Aras S, Varli M, Uzun B, Atli T, Keven K, Turgay M. Comparison of different glomerular filtration methods in the elderly: which formula provides better estimates? Ren Fail 2012; 34: 435-441.
10. Millward MJ, Webster LK, Toner GC, Bishop JF, Rischin D, Stokes KH, Johnston VK, Hicks R. Carboplatin dosing based on measurement of renal function – experience at the Peter MacCallum Cancer Institute. Aust NZ J Med 1996; 26: 372–379.
11. Al-Khader AA, Tamim H, Sulaiman MH, Jondeby MS, Taher S, Hejaili FF, Ghamdi G, Ahmed Flaiw A, Hakami A. What is the most appropriate formula to use in estimating glomerular filtration rate in adult Arabs without kidney disease? Ren Fail 2008; 30: 205-208.
12. Aparicio AS, Mojiminiyi S, Kay JD, Shepstone BJ, De Ceulaer K, Serjeant GR. Measurement of glomerular filtration rate in homozygous sickle cell disease: a comparison of 51Cr-EDTA clearance, creatinine clearance, serum creatinine and beta-2 microglobulin. J Clin Pathol 1990; 43: 370-372.
13. Odlind B, Hällgren R, Sohtell M, Lindström B. Is 125I-iothalamate an ideal marker for glomerular filtration? Kidney Int 1985; 27: 9-16.
14. Gunasekara RD, Allison DJ, Peters AM. Glomerular filtration rate in relation to extracellular fluid volume: similarity between Tc-99m DTPA and inulin. Eur J Nucl Med 1996; 23: 49-54.
15. Waller DG, Keast CM, Fleming CS, Ackery DM. Measurement of glomerular filtration rate with Tc-99m DTPA: comparison of plasma clearance techniques. J Nucl Med 1987; 28: 372-377.
16. Shemesh O, Golbetz H, Kriss JP, Myers BD. Limitations of creatinine as a filtration marker in glomerulopathic patients. Kidney Int 1985; 28: 830-838.
17. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Am J Kidney Dis 2002; 39: S1-S266.
18. Gates GF. Glomerular filtration rate: estimation from fractional renal accumulation of 99mTc-DTPA (stannous). Am J Roentgenol 1982; 138: 565-570.
19. Itoh K. Comparison of methods for determination of glomerular filtration rate: Tc-99m-DTPA renography, predicted creatinine clearance method and plasma sample method. Ann Nucl Med 2003; 17: 561-565.
20. Hoek FJ, Kemperman FA, Krediet RT. A comparison between cystatin C, plasma creatinine and the Cockcroft and Gault formula for the estimation of glomerular filtration rate. Nephrol Dial Transplant 2003; 18: 2024-2031.
21. Sawyer WT, Canaday BR, Poe TE, Webb CE, Porter RS, Gal P, Joyner PU, Berry JI. A multicenter evaluation of variables affecting the predictability of creatinine clearance. Am J Clin Pathol 1982; 78: 832-883.
22. Blaufox MD, Aurell M, Bubeck B, Fommei E, Piepsz A, Russell C, Taylor A, Thomsen HS, Volterrani D. Report of the radionuclides in nephrourology committee on renal clearance. J Nucl Med 1996; 37: 1883-1890.
23. Srinivas S, Annigeri RA, Mani MK, Rao BS, Kowdle PC, Seshadri R. Estimation of glomerular filtration rate in South Asian healthy adult kidney donors. Nephrology 2008; 13: 440-446.
24. Levey AS, Coresh J, Greene T, Marsh J, Stevens LA, Kusek JW, Van Lente F. Expressing the modification of diet in Renal Disease Study equation for estimating glomerular filtration rate with standardized serum creatinine values. Clin Chem 2007; 53: 766.
25. Issa N, Meyer KH, Arrigain S, Choure G, Fatica RA, Nurko S, Stephany BR, Poggio ED. Evaluation of creatinine-based estimates of glomerular filtration rate in a large cohort of living kidney donors. Transplantation 2008; 86: 223-230.
26. Christensen AB, Groth S. Determination of Tc-99m DTPA clearance by a single plasma method. Clin Physiol 1986; 6: 579-588.
27. Itoh K, Tsushima S, Tsukamoto E, Tamaki N. Accuracy of plasma sample methods for determination of glomerular filtration rate with 99mTc-DTPA. Ann Nucl Med 2002; 16: 39-44.
28. Perrone RD, Steinman TI, Beck GJ, Skibinski CI, Royal HD, Lawlor M, Hunsicker LG. Utility of radioisotopic filtration markers in chronic renal insufficiency: simultaneous comparison of 125I-iothalamate, 169Yb-DTPA, 99mTc-DTPA, and inulin. The Modification of Diet in Renal Disease Study. Am J Kidney Dis 1990; 16: 224-235.

29. Goates JJ, Morton KA, Whooten WW, Greenberg HE, Datz FL, Handy JE, Scuderi AJ, Haakenstad AO, Lynch RE. Comparison of methods for calculating glomerular filtration rate: technetium-99m-DTPA scintigraphic analysis, protein-free and whole-plasma clearance of technetium-99m-DTPA and iodine-125-iothalamate clearance. J Nucl Med 1990; 31: 424-429.

30. Rehling M, Moller ML, Thamdrup B, Lund JO, Trap-Jensen J. Simultaneous measurement of renal clearance and plasma clearance of 99mTc-labelled diethylenetriamine penta-acetate, 51Cr-labelled ethylenediaminetetra-acetate and inulin in man. Clin Sci 1984; 66: 613-619.

31. Waller DG, Keast CM, Fleming JS, Ackery DM. Measurement of glomerular filtration rate with technetium-99m DTPA: comparison of plasma clearance techniques. J Nucl Med 1987; 28: 372-337.

32. Gates GF. Split renal function testing using 99mTc-DTPA. A rapid technique for determining differential glomerular filtration. Clin Nucl Med 1983; 8: 400-405.

33. Itoh K, Tsushima S, Tsukamoto E, Tamaki N. Reappraisal of single-sample and gamma camera methods for determination of the glomerular filtration rate with 99mTc-DTPA. Ann Nucl Med 2000; 14: 143-150.

34. Duran E, Prigent A, Gaillard J. Comparison between 9 methods for estimation of glomerular filtration rate (GFR) with simultaneous injection of 51Cr-EDTA and 99mTc-DTPA. In: Taylor A Jr, Nally J, Thomsen H, editors. Radionuclides in Nephrourology. Reston, VA, USA: Society of Nuclear Medicine; 1997. pp. 112-120.

35. De Santo NG, Anastasio P, Cirillo M, Santoro D, Spitali L, Mansi L, Celentano L, Capodicasa D, Cirillo E, Del Vecchio E et al. Measurement of glomerular filtration rate by the 99mTc-DTPA renogram is less precise than measured and predicted creatinine clearance. Nephron 1999; 81: 136-140.

36. Aydin F, Güngör F, Cengiz AK, Tuncer M, Mahsereci E, Ozdem S, Cenkçi M, Karayalçin B. Comparison of glomerular filtration rate measurements with the two plasma sample and single plasma sample, gamma camera Gates, creatinine clearance, and prediction equation methods in potential kidney donors with normal renal function. Nucl Med Commun 2008; 29: 157-165.

37. Assadi M, Eftekhari M, Hozhabrosadati M, Saghari M, Ebrahimi A, Nabipour I, Abbasi MZ, Moshtaghi D, Abbaszadeh M, Assadi S. Comparison of methods for determination of glomerular filtration rate: low and high-dose Tc-99m-DTPA renography, predicted creatinine clearance method, and plasma sample method. Int Urol Nephrol 2008; 40: 1059-1065.

38. Gaspari F, Ferrari S, Stucchi N, Centemeri E, Carrara F, Pellegrino M, Gherardi G, Gotti E, Segoloni G, Salvadori M et al. Performance of different prediction equations for estimating renal function in kidney transplantation. Am J Transplant 2004; 4: 1826-1835.

39. Coresh J, Stevens LA. Kidney function estimating equations: Where do we stand? Curr Opin Nephrol Hypertens 2006; 15: 276-284.

40. Poggio ED, Wang X, Greene T, Van Lente F, Hall PM. Performance of the modification of diet in renal disease and Cockcroft-Gault equations in the estimation of GFR in health and in chronic kidney disease. J Am Soc Nephrol 2005; 16: 459-466.

41. Vervoort G, Willems HL, Wetzels JFM. Assessment of glomerular filtration rate in healthy subjects and normoalbuminuric diabetic patients: validity of a new (MDRD) prediction equation. Nephrol Dial Transpl 2002; 17: 1909-1913.