Correlation of the Renal Cortex Volume With the Glomerular Filtration Rate in Live Donors for Renal Transplantation

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ABSTRACT

Introduction. As a pretransplantation evaluation, renal function is determined by the glomerular filtration rate (GFR) with the use of renal scintigraphy (RS) and the estimated glomerular filtration rate (eGFR). To date, there are few studies that correlate renal cortex volume with eGFR determined with renal gammagram (GR) and eGFR by equations (Cockroft-Gault, Modification of Diet in Renal Disease, and Chronic Kidney Disease Epidemiology Collaboration equation) in Latin American living donors.

Aim. This study sought to determine whether there is correlation of the volume of the renal cortex by Herts equation with the GFR determined with renal gammagram (GFR-GR).

Patients and Methods. This was an analytical, observational, and cross-sectional study. A review of the donor charts from January 1, 2014, to December 1, 2014, with a complete clinical file, kidney measurements, predonation tomography volume, and eGFR by different formulas and by renal scintigraphy.

Results. Thirty-three donors were included, 51.5% male and 48.5% female. The mean age was 38.58 ± 10 years, with an average volume of 127.83 ± 28.30 mL, with diethylenetriamine-pentaacetate (DTPA) of 54.80 ± 7.13 mL/min/1.73 m^2 in the donated kidney. Spearman correlation showed the best association with the Herts equation ($r = 0.346$) reaching significance ($P = .049$) when comparing the different equations against the GFR with DTPA. Using the Bland-Altman method, the lowest variability and best significance was verified with the same equation compared to the other formulas ($P = .0002$).

Conclusions. There is no consensus regarding which is the best formula for calculating the GFR of both kidneys. Of the different formulas, the one that best correlated with the GFR was the Herts method, which uses the volume of the kidney.

CURRENTLY, reference methods for the determination of glomerular filtration rate (GFR) are the clearance of inulin and renal scintigraphy [1,2], which involves the intravenous administration of drugs labeled with radioactive isotopes such as technetium diethylenetriamine-pentaacetate (99mTc-DTPA) [2], which is the radiotracer

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that has higher use and diffusion at present [2,3]. In addition, equations are used to calculate the GFR in an economical, simple, brief, practical, safe, and widely available form, such as: Cockroft-Gault (CG), Modification of Diet in Renal Disease (MDRD), and Chronic Kidney Disease Epidemiology Collaboration equation (CKD-EPI) [4,5], which have been designed for use in patients with chronic renal disease [6]. For this reason, they tend to underestimate the results when comparing with those obtained from reference methods in people with intact renal function. The volume of kidney graft has been reported to be a good predictor of renal recipient function [7,8]. Previous studies indicate that there is a correlation between renal cortex volume and estimated glomerular filtration rate (eGFR) in living donors [8]. As we reported previously, Jeon et al. also demonstrated that the volume of a healthy kidney is related to body parameters and correlates to nephrectomized kidney weight and functions [9,10]. According to the guidelines of the National Kidney Foundation–Kidney Disease Quality Outcome Initiative (NKF-KDOQI), prediction equations taking into account serum creatinine level (sCr) and given variables for creatinine production, such as age, sex, and race, are recommended for GFR estimation in clinical practice [11]. New equations for measuring GFR have been requested [6,12], and use of equations based on kidney volume is strongly recommended [6,12]. This correlation of computed tomography (CT)-measured kidney volume with renal function was incorporated by Herts et al. into a mathematical model to estimate GFR in potential kidney donors [12].

AIM

This study sought to determine the correlation between the volume of the renal cortex determined by CT, used in the Herts formula, with the glomerular filtration rate determined by DTPA, compared with the traditional formulas in live donors for renal transplantation.

METHODOLOGY

This was an observational, analytical, transversal, retrospective study.

Population Sample

The population sample consisted of living donors for renal transplantation, accepted by the transplant committee, for the period from January 1, 2015, to December 31, 2015, with a complete clinical file, 99mTc-DTPA renal gammagram, and volumetry by computed axial tomography. Excluded were those cases in which the calculation of GFR by DTPA was not accurate, the patient refused to participate in the study, or it would not have been possible to accurately calculate the volume of the renal cortex by CT. We compared the performance of creatinine-based GFR values determined using MDRD, CG equation, CKD-EPI, and volume-based GFR (vGFR) determined using the equation developed by Herts for calculating volume-based GFR using kidney volume obtained from CT scanning, serum creatinine, age, height, weight, and sex. In addition, renal measures (length, width, thickness, weight) obtained at the moment of donor nephrectomy were taken into account.

Volume Determination

The volume of each of the kidneys by angiographic tomography was determined by the Aquilion tomograph (Toshiba Medical Systems, Otawara, Japan). Numerous cuts were made with an average thickness of 0.5 to 1.0 mm. Both the single phase and the contrast phase were used. Iodine (Omnipaque) iohexol 350 mg/dL was used as the intravenous contrast (General Electric Health Care, Cork, Ireland), as well as Pamidol iomamidol 370 mg/dL (JB Ch & P Ltd, Panoli, India). A total of 120 mL of iodinated contrast medium was administered in an intravenous infusion of 2.5 to 3.5 mL/min. On average, the arterial phase was obtained 30 seconds after infusion of intravenous contrast. The venous phase was obtained 60 seconds after contrast infusion. Image reconstruction was performed axially, coronally, and sagittally, with average cuts of 0.5 to 1.0 mm. Subsequently, the renal cortex volume of each of the donor kidneys was performed, using software with automatic renal parenchymal density formula defined by Hounsfield units (Vitrea Core, tomographic reconstruction, Vital Images, Minnetonka, MN). The tissues adjacent to the cortex were manually adjusted with multiplane reconstructions. All of this was carried out by a single radio-doctor. Renal volumetry was performed based on radiographic reconstructions from the CT of both and of each of the kidneys. Once the renal tomography reconstruction is performed in 3 dimensions, the radiographic information is analyzed using the Vitrea Core software (Vital Images) for the automatic determination of the volume of the cortex of both kidneys of the donor.

Renal Gammagram

Renal gammagram was performed using the 2-detector nuclear gamma camera e.cam, associated with a high-resolution, low-energy multipurpose parallel collimator (Siemens Healthcare Global, Erlangen, Germany) with the Tc-DTPA radiotracer (Hovione 99Tc-DTPA, Hovione Worldwide, Lourdes, Portugal). A single dose of 315 ± 55 mBq of 99Tc-DTPA was administered intravenously, equivalent to 8.5 ± 1.5 mCi of the drug. After the application of the same, the dynamic images were recorded by second during the first minute, and then every 30 seconds for 20 minutes. Region-of-interest images were analyzed. The interpretation of the GFR was performed by a single nuclear physician from the first to the third minute after radiotracer infusion. Thus the GFR of both kidneys and of each one separately was determined.

The prediction equations that we used to estimate GFR were:

1. CG = ((140 − age) (weight/72) (sCr × 0.85 if female).
2. MDRD = ((170 × $sCr^{-0.999}$) ($age^{-1.176}$) (1.0 if male or 0.762 if female) (1.0 if white or 1.18 if black) ($blood\ urea\ nitrogen^{-0.17}$) ($alb^{0.318}$)).
3. CKD-EPI = ((141) $(sCr/0.90 \text{ if male or } 0.70 \text{ if female})^{-0.411 \text{ if male or } -0.329 \text{ if female}}$ $(sCr/0.90 \text{ if male or } 0.70 \text{ if female})^{-1.209}$ $(0.993)^{age}$ (1.018 if female) (1.159 if black).
4. GFR CC (glomerular filtration rate by creatinine clearance) = ((Cr) (Vol_u))/(Scr)).
5. Herts formula = vGFR = ((70.77 − (0.444(age)) + (0.366 × weight) + (0.200 × VCR) − (37.317 × sCr)).

STATISTICAL ANALYSIS

The correlation between quantitative variable and quantitative variable was performed by Spearman correlation and