Usefulness of Multi-Detector Computed Tomography Scanning as a Replacement for Diethylenetriamine Pentaacetic Acid

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ABSTRACT

Background. Diethylenetriamine pentaacetic acid (DTPA) and multi-detector computed tomography (MDCT) can predict postoperative estimated glomerular filtration rate (eGFR) in a live kidney donor. Accordingly, we compared predicted eGFR measured by use of DTPA and MDCT.

Methods. From January 2013 to May 2015, 264 live kidney donors were enrolled. All donors underwent preoperative DTPA and MDCT, and bilateral renal cortex volume was measured by use of MDCT. We estimated DTPA-eGFR [remaining split renal function (%) × preoperative eGFR] and Vol-eGFR [remaining renal volume/total renal volume (%) × preoperative eGFR] and analyzed DTPA-eGFR, Vol-eGFR, and Modification of Diet in Renal Disease (MDRD)-eGFR during week 1 and in months 1, 3, and 6. Additionally, we compared DTPA-eGFR and Vol-eGFR by use of the formula ΔeGFR (maximum eGFR minus minimum eGFR during 6 months).

Results. The mean DTPA-eGFR and Vol-eGFR values (mL/min/1.73 m^2) were 52.97 ± 10.32 and 51.26 ± 10.26, respectively. Predictions of the dominant side did not agree in 113 of 303 (37.3%) cases. Postoperative MDRD-eGFR exhibited a statistically significant correlation with total renal volume, DTPA-eGFR, and Vol-eGFR ($P < .0001$). A significant correlation was found between ΔeGFR and total renal volume, DTPA-eGFR, and Vol-eGFR ($P < .0001$). Receiver operating characteristic curves were generated to predict the possibility of eGFR <60 mL/min/1.73 m^2 at 6 months, using DTPA-eGFR and Vol-eGFR, which indicated that DTPA-eGFR (area under the curve = 0.858; $P < .0001$) and Vol-eGFR (area under the curve = 0.878; $P < .0001$) could predict chronic kidney disease class III at 6 months.

Conclusions. MDRD-eGFR, Vol-eGFR, and DTPA-eGFR were significantly correlated. Moreover, Vol-eGFR and DTPA-eGFR exhibited high predictive value for chronic kidney disease class III at 6 months, whereas Vol-eGFR was a good predictor of renal function recovery.

IT has been established that kidney transplantation is a better method for improving the quality of life in patients with end-stage renal disease (ESRD) than is hemodialysis [1]. However, a detailed surgical plan is required to ensure the safety of the live kidney donor at the time of the surgery to ensure optimal transplant results [2]. As well, the results of various tests are evaluated to minimize the progression to ESRD in live kidney donors. Accordingly, we assessed 24-hour urine creatinine clearance, the estimated

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glomerular filtration rate (eGFR), diethylenetriamine pentaacetic acid (DTPA) clearance and performed multidetector computed tomography (MDCT), which enabled the evaluation of renal function in the live kidney donor.

To determine the side of the nephrectomy, DTPA scintigraphy is used to evaluate split renal function [3]. Nonetheless, the MDCT reconstruction images yield accurate measurements of the kidney volume. As well, MDCT provides anatomical details of the kidney, vasculature, and the collecting system and aids in the diagnosis of kidney abnormalities [4,5]. Furthermore, MDCT has shown a high level of agreement with DTPA scans in the determination of split renal function; thus, the feasibility of only performing MDCT in live kidney donors has been proposed [6]. Both DTPA renography and MDCT can predict postoperative eGFR in a live kidney donor. Accordingly, the aim of our study was to compare predicted eGFR values measured by use of a DTPA scan and MDCT.

METHODS

The study was reviewed and approved by the institutional review board and the ethics committee. Preoperative and postoperative evaluations were performed in 264 patients who underwent donor nephrectomy from January 2013 to May 2015. All surgeries were performed by 2 surgeons who used video-assisted mini-laparotomy surgery (VAMS) techniques [7]. We evaluated routine blood tests, DTPA renal scans, and CT angiography in all live kidney donors. After surgery, routine lab tests were performed daily for 3 days until the patients were discharged. We followed the patients postoperatively for 6 months. In month 6, we classified the donors who exhibited eGFR rates <60 mL/min/1.73 m^2 as the chronic kidney disease (CKD) group. The Modification of Diet in Renal Disease (MDRD) formula was used to calculate eGFR rates. Before surgery, MDCT and DTPA scans were performed on all patients and the bilateral renal volume was measured by MDCT. We estimated DTPA-eGFR [remaining split renal function (%) × preoperative eGFR] and Vol-eGFR [remaining renal volume/total renal volume (%) × preoperative eGFR], and analyzed DTPA-eGFR, Vol-eGFR, and MDRD-eGFR in week 1 and in months 1, 3, and 6. As well, we compared DTPA-eGFR and Vol-eGFR by use of the formula ΔeGFR (maximum eGFR minus minimum eGFR during 6 months).

CT Protocols

All CT examinations were performed with the use of a standardized examination protocol and a multi-slice, 64–detector row helical CT scanner (Lightspeed, GE Medical Systems; Milwaukee, Wis, United States). Scanning was initiated through the use of a scout image that covered the abdomen. A pre-contrast image was acquired with 2.5-mm slices and a table rotation time of 0.5 seconds at 120 kV and 100 mAs. The arterial and venous phases were obtained 12 seconds and 60 seconds after the initiation of the contrast bolus, respectively. The arterial phase included a volume covering the diaphragm to the pelvis. After acquiring the image, the arterial and venous phase images were reconstructed through the use of 3-mm and 1-mm axial images and 3-mm coronal images. As well, a 3-dimensional reconstruction image was acquired with the use of 0.625-mm slices. The 3-dimensional images of both kidneys were segmented and measured with the use of the workstation multiplanar reformation and tissue segmentation packages. The functional renal parenchyma was outlined in a transverse section and then multiplied by slice thickness to obtain the renal volume (Fig 1).

DTPA Protocols

For 99mTc-DTPA scintigraphy, the donors were hydrated with 5 mL water/kg body weight 30 minutes before the administration of 370 MBq of DTPA. To measure GFR from the DTPA plasma clearance, 3 mL of blood was collected from all donors 4 hours after injection at a site that was distinct from the radionuclide injection site. GFR was measured by use of a single sample and the Christensen-Groth method (Fig 1) [8].

The relationships between the values measured perioperatively and the recovery of renal function were analyzed by Pearson correlate analysis at 6 months. We classified the donors who exhibited eGFR rates <60 mL/min/1.73 m^2 as the CKD group, and receiver operating characteristic curves were generated. A value of $P < .05$ was regarded as statistically significant. All data analyses were conducted with the use of SPSS software version 23.0 (IBM SPSS Statistics, IBM Corporation; Armonk, NY, United States).

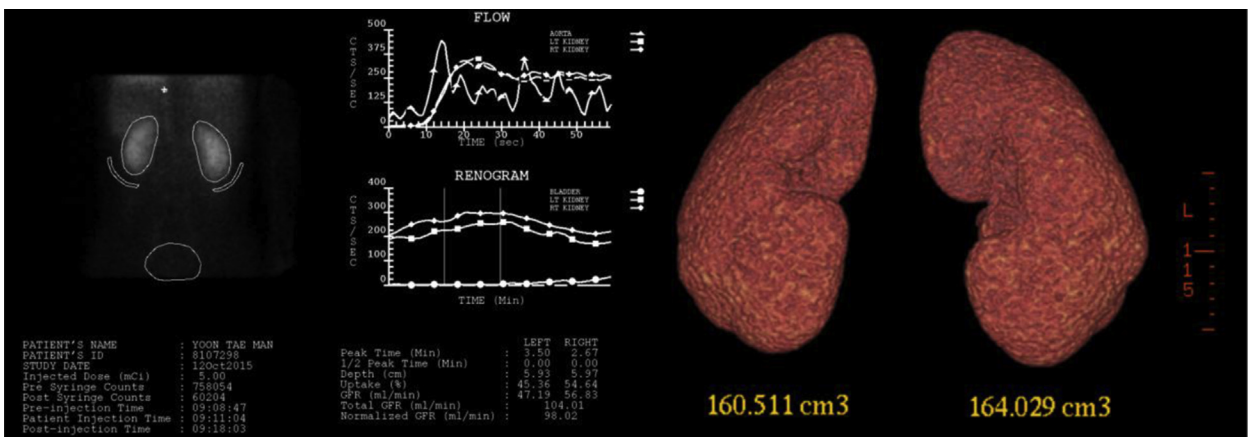

Fig 1. Renogram and split renal function by use of DTPA *(left)*; 3-dimensional kidney volume by use of MDCT *(right)*.