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# Utility of the Japanese Glomerular Filtration Rate Equation in Estimating Glomerular Filtration Rate of Donor Kidney

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## ABSTRACT

**Background.** An equation for the estimated glomerular filtration rate (eGFR) is generally used for evaluating renal function in Japan.

**Objective.** To assess the accuracy of the preoperative eGFR for estimating kidney donors' measured glomerular filtration rate (mGFR).

**Methods.** Between April 2009 and August 2014, 91 Japanese living kidney donors were included in this study. The eGFR was calculated as follows: eGFR $=$ 194 $\times$ serum creatinine$^{-1.094}$ $\times$ Age$^{-0.287}$ (and $\times$ 0.739 for women), and the mGFR was evaluated using inulin clearance. The preoperative eGFR was then compared with the mGFR.

**Results.** Patients included 27 men and 64 women with a mean age of 56.8 $\pm$ 9.5 years (range, 36–79 years), mean body surface area of 1.56 $\pm$ 0.14 m$^2$ (range 1.27–1.92 m$^2$), mean body mass index of 22.3 $\pm$ 2.3 kg/m$^2$ (range 14.0–27.0 kg/m$^2$), and mean serum creatinine level of 0.66 $\pm$ 0.14 mg/dL (range 0.39–0.97 mg/dL). The mean eGFR was 81.3 $\pm$ 14.2 mL/min/1.73 m$^2$ (range 45.5–125.9 mL/min/1.73 m$^2$), and the mean mGFR was 89.0 $\pm$ 15.5 mL/min/1.73 m$^2$ (range 45.4–130.7 mL/min/1.73 m$^2$). The eGFR was significantly lower than the mGFR ($P < .001$). The correlation coefficient for the relationship between the eGFR and mGFR values was 0.503, and the mean difference between the 2 values was $-7.8$ (8.7%).

**Conclusions.** Although the eGFR correlated with the mGFR, the eGFR values did not accurately estimate the mGFR in living kidney donors. Therefore, it is necessary to evaluate the mGFR, especially in marginal kidney donors.

THE SHORTAGE of deceased donors is a serious problem in Japan; therefore, living kidney transplantation has become increasingly common. In living kidney transplantation, the safety of the donor as well as that of the recipient is important, both during the preoperative period and after transplantation. It is especially important to precisely evaluate the donor's renal function so that it does not worsen after donor nephrectomy.

The Japanese Society of Nephrology developed an equation for estimated glomerular filtration rate (eGFR) from inulin clearance (Cin) data collected from 413 Japanese patients [1]. The equation for eGFR is generally used for evaluating renal function in Japan. However, Matsuo et al reported that the equation for eGFR may not be applicable to the healthy population because it was derived mostly from patients with chronic kidney disease [1]. Therefore, we investigated whether the eGFR equation can be used to evaluate kidney donors' renal function before transplantation.

## PATIENTS AND METHODS

Between April 2009 and August 2014, 100 living kidney transplantations were performed at our institution. Among them, 91 donors had their Cin measured. The donors' measured glomerular filtration rate (mGFR) was estimated using their Cin. We assessed the accuracy of the preoperative eGFR for the mGFR before donor

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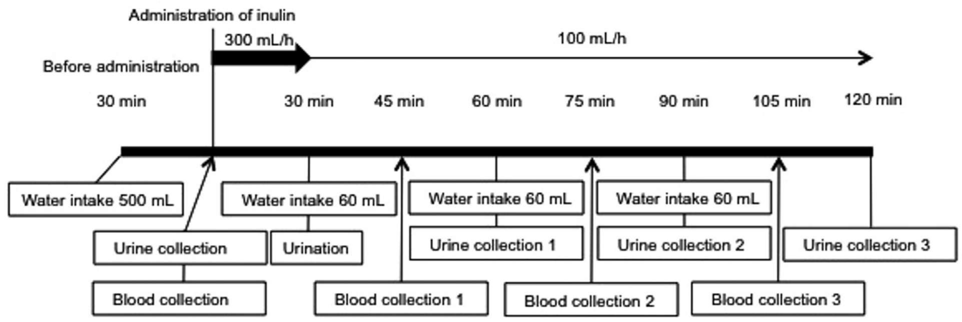


**Fig 1.** Method for measuring the insulin clearance.

nephrectomy. We used the eGFR equation and the method for measuring Cin suggested by the Japanese Society of Nephrology.

The eGFR was calculated as follows:

eGFR (mL/min/1.73 m$^2$) = 194 × serum creatinine (Scr)$^{-1.094}$ × Age$^{-0.287}$ (×0.739 for women)

The method for measuring Cin is shown in Fig 1. All patients fasted at the day of examination and drank 500 mL of water 30 minutes before inulin was administered. We performed urine and blood collections before inulin was administered. These collections were a blank test of inulin in urine and blood. Simultaneously, we measured Scr. All patients received a 2-hour continuous intravenous infusion of 1% inulin at 300 mL/hour for the first 30 minutes and then at 100 mL/hour for the remaining 90 minutes. All patients discharged all urine 30 minutes after inulin was administered. Three sets of serum and urine samples were collected. We collected blood at 45, 75, and 105 minutes, whereas urine was collected at 60, 90, and 120 minutes after inulin was administered. All patients were hydrated with 60 mL of water at 30, 60, and 90 minutes after inulin was administered. Cin was calculated based on serum and urine inulin concentrations and urine volume. The mean of 3 inulin clearance values was used as the mGFR, and standardized for a body surface area of 1.73 m$^2$. Inulin and Scr were measured by enzymatic methods. All donors were given adequate verbal instruction and provided written informed consent.

### Statistical Analysis

Data are expressed as mean ± standard deviation. For statistical analysis, the Student *t* test was used to compare differences between the eGFR and mGFR. Bias of the equation was expressed as both a mean difference and a mean percentage difference between the eGFR and mGFR (eGFR−mGFR). Precision between the eGFR and mGFR was assessed by Pearson's correlation coefficient (r). A difference with a $P$ value $< .05$ was considered statistically significant. JMP, version 11.0 (SAS Institute, Inc., Cary, N.C., United States) was used to perform the statistical analyses.

## RESULTS

The characteristics of this study population are shown in Table 1. Patients included 27 men and 64 women with a mean age of 56.8 ± 9.5 years (range 36–79 years), mean body surface area of 1.56 ± 0.14 m$^2$ (range 1.27–1.92 m$^2$), mean body mass index of 22.3 ± 2.3 kg/m$^2$ (range 14.0–27.0 kg/m$^2$), and mean serum creatinine level of 0.66 ± 0.14 mg/dL (range, 0.39–0.97 mg/dL). The mean eGFR was 81.3 ± 14.2 mL/min/1.73 m$^2$ (range 45.5–125.9 mL/min/1.73 m$^2$), and the mean mGFR was 89.0 ± 15.5 mL/min/1.73 m$^2$ (range 45.4–130.7 mL/min/1.73 m$^2$).

The eGFR was significantly lower than the mGFR in combined potential donors ($P < .001$). The r for the relationship between the eGFR and mGFR values was 0.503, and the mean difference between the 2 values was −7.8 (8.7%), with a root mean square error of 13.5 mL/min/1.73 m$^2$. Similarly, when we segregated the sexes, the eGFR was significantly lower than the mGFR (Fig 2, A–C; Table 2).

## DISCUSSION

According to the data obtained from the Japanese Renal Transplant Registry in Japan in 2014, 1,598 kidney transplantations were performed. The number of kidney transplantations remained roughly unchanged recently. However, the number of deceased kidney transplantations decreased whereas living kidney transplantations increased, accounting for >90% of transplantations [2]. It is important that a living donor is safe both during the preoperative period and after transplantation. It is especially important to precisely evaluate the donor's renal function to minimize the risk of developing preuremia or even renal failure during the donor's lifetime.

In Japan, the donor's renal function is generally evaluated by the creatinine clearance (Ccr) measured from a 24-hour urine sample. However, in potential living kidney donors or patients with nearly normal renal function, some investigations have reported that the Ccr may underestimate or overestimate the GFR [3–5]. Therefore, at our institution, almost all donor renal function is evaluated by the

**Table 1. Patients' Characteristics (Mean ± Standard Deviation, Range)**

| | |
|---|---|
| Sex | Men 27, women 64 |
| Age (years) | 56.8 ± 9.5 (36–79) |
| BSA (m$^2$) | 1.56 ± 0.14 (1.27–1.92) |
| BMI (kg/m$^2$) | 22.3 ± 2.3 (14.0–27.0) |
| Serum creatinine (mg/dL) | 0.66 ± 0.14 (0.39–0.97) |
| eGFR (mL/min/1.73 m$^2$) | 81.3 ± 14.2 (45.5–125.9) |
| mGFR (mL/min/1.73 m$^2$) | 89.0 ± 15.5 (45.4–130.7) |

Abbreviations: BSA, body surface area; BMI, body mass index; eGFR, estimated glomerular filtration rate; mGFR, measured glomerular filtration rate.