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Assessment of calculated glomerular filtration rate using percutaneous nephrostomy creatinine clearance

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Abstract

Background: Radionuclide scintigraphy is considered the most widely used method for estimation of glomerular filtration rate (GFR) in clinical use. The present study was conducted to assess calculated glomerular filtration rate (cGFR) using percutaneous nephrostomy creatinine clearance and comparing it with measured glomerular filtration rate (mGFR) calculated by radionuclide scintigraphy.

Materials & Methods: 40 cases of kidney disease of both genders were included. The mGFR and cGFR estimation was done after complete stabilization of the patient and resolution of the indication for which PCN was inserted and after stabilization of PCN output. The DTPA/EC scan was performed by Gates method.

Results: Out of 40 patients, males were 22 and females were 18. mGFR (mean) was 11.4 ml/min, cGFR (mean) was 7.42 ml/min, highest calculated GFR was 8.74 ml/min, mGFR <15 was seen in 27, mGFR 15-30 was seen in 7, mGFR >30 was seen in 5 and mGFR could not be calculated in 1 patient. A strong overall correlation was found between the two methods of GFR estimation.

Conclusion: GFR calculated by PCN creatinine clearance can be used to estimate kidney function when radionuclide scan is not available. However, further studies are required due to small sample size of our study.

Keywords: GFR, scintigraphy, kidney

Introduction

Radionuclide scintigraphy is currently the most widely used method for estimation of glomerular filtration rate (GFR). It is also the only noninvasive method that can estimate differential renal function, which is more relevant to urologists. Although computerized tomography (CT) volumetry has also been described for estimating the split renal function, unlike radionuclide scanning, it does not estimate the absolute GFR of each kidney^[1].

Glomerular filtration is relevant for smaller, nonprotein-bound substances. Tubular secretion is a more common pathway for protein-bound compounds^[2]. In most cases, the best measure of kidney function is the GFR, which has generally been accepted as a measure of functioning kidney mass. In addition, measures to directly and indirectly measure GFR have been well validated, and there is extensive experience with their operational characteristics. Although measurement of tubular secretion can be performed, it is more laborious and of unclear clinical significance^[3].

Creatinine clearance method is the most commonly used method for estimating global GFR despite its inaccuracies, as it is easy to perform and gives results adequate for clinical purposes. In urology, many patients require percutaneous nephrostomy (PCN) insertion for emergency management of various disease conditions like pyonephrosis, distal obstruction etc.^[4] In developing countries, radionuclide scintigraphy is available only at few centres. The creatinine clearance calculated from this PCN urine output provides GFR of that unilateral kidney of the side of PCN^[5]. The present study was conducted to assess calculated glomerular filtration rate (cGFR) using percutaneous nephrostomy creatinine clearance and comparing it with GFR measured by technetium-99m diethylene-triamine-penta-acetic acid (DTPA) scan or technetium-99m ethylene-di-cysteine (EC) scan (mGFR).

Materials and Methods

The present study was conducted among 40 cases of kidney disease of both genders. All were informed regarding the study and their written consent was obtained. Data related to patients such as name, age, gender etc. was recorded. The mGFR and cGFR estimation was done after complete stabilization of the patient and resolution of the indication for which PCN was inserted and after stabilization of PCN output. The DTPA/EC scan was performed by Gates method from a single center. As EC scan gives only effective renal plasma flow (ERPF) values, approximate GFR estimate was calculated by dividing ERPF by 3.5, which is calculated as follows:

ERPF is given by the formula: ERPF = renal plasma flow (RPF) × extraction ratio.

The GFR is related to RPF as follows: GFR = RPF × filtration fraction.

The value of filtration fraction in humans is 0.2. The extraction ratio of EC is 0.7.

Thus after substitution of the above values: GFR = ERPF/3.5

For cGFR estimation, 24 h PCN output was collected for 4 consecutive days. The total PCN output was measured (V) (milliliters) and sent for urine creatinine estimation (U) (mg/dl). Blood sample was also drawn and sent for serum creatinine (P) (mg/dl) measurement at the same time.

The GFR was calculated using the formula: GFR (ml/min) = (U × V) / (24 × 60 × P).

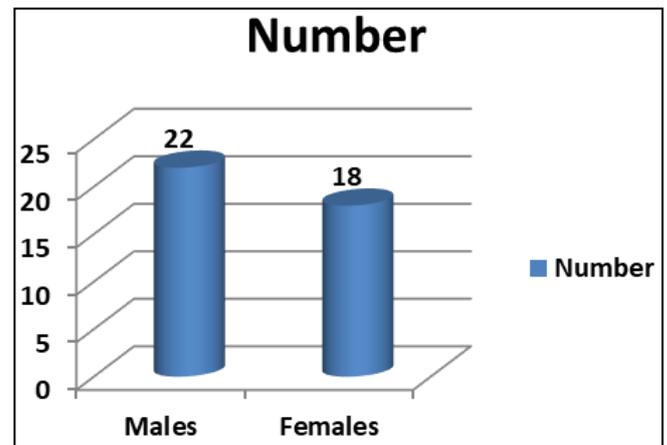
Results thus obtained were subjected to statistical analysis. p value less than 0.05 was considered significant.

Results

Table 1: Distribution of patients

Total- 40		
Gender	Males	Females
Number	22	18

Table I, graph I shows that out of 40 patients, males were 22 and females were 18.



Graph I: Distribution of patients

Table 2: Assessment of parameters

	Parameters	Value
	mGFR (mean), ml/min	11.4
	cGFR (mean), ml/min	7.42
	Highest calculated GFR, ml/min	8.74
mGFR	mGFR <15	27
	mGFR 15-30	7
	mGFR >30	5
	mGFR could not calculated	1

Table II shows that mGFR (mean) was 11.4 ml/min, cGFR (mean) was 7.42 ml/min, highest calculated GFR was 8.74 ml/min, mGFR <15 was seen in 27, mGFR 15-30 was seen in 7,

mGFR >30 was seen in 5 and mGFR could not calculated in 1 patient.

Table 3: Result of comparative analysis

Observation	Comparison with cGFR	Comparison with highest cGFR
Overall correlation	r- 0.540	r-0.542
Patients with comparable GFR	22	23
Patients with noncomparable GFR	17	16
GFR could not be calculated on DTPA	1	1

Table III shows that a strong overall correlation was found between the two methods of GFR estimation.

Discussion

The glomerular filtration rate (GFR) is a standard measure of renal function and can be determined by measuring the clearance of a molecule freely filtered through the glomerulus (measured GFR, mGFR) [6]. Although urinary inulin clearance is the gold standard method for determining mGFR, measuring the plasma clearance of 51Cr-EDTA is less cumbersome to perform and provides comparatively accurate results. It is, therefore, the method used most commonly in the UK and throughout Europe, and is the technique recommended by the British Nuclear

Medicine Society (BNMS) [7].

It is important to have accurate reference ranges for GFR. The current BNMS guideline quotes a reference range based on a series of mGFRs in 503 healthy subjects published in 1981: mean GFR in young adults was 105 mL/min/1.73 m² which declined by 4 mL/min/ 1.73 m² per decade up to 50 years of age, and 10 mL/min/ 1.73 m² per decade thereafter. Similarly, in the largest study to date of mGFRs in a healthy population, which included 1057 prospective living kidney donors, mGFR declined by 4 mL/min/1.73 m² per decade up to the age of 45 years, and 8 mL/min/1.73 m² per decade thereafter.⁸ The present study was conducted to assess calculated glomerular filtration rate using percutaneous nephrostomy creatinine clearance.

Patil *et al.* [9] in their study a total of 46 patients in whom PCN was inserted as an emergency measure in an obstructed kidney and for whom diethylene-triamine-penta-acetic acid/ethylene-di-cysteine (DTPA/EC) scan was also done (Gates method) were analyzed retrospectively. PCN creatinine clearance was calculated for 3 consecutive days. Overall strong correlation was found between the two GFR values (Pearson's $r = 0.540692$, $P < 0.001$). Totally 26 patients (56.52%) had comparable GFR values ($P > 0.05$). Among the 36 patients with borderline functioning kidneys, DTPA/EC scan significantly over-estimated GFR in one-third of the patients. The management plan was changed in 7 out of those patients (46.67%), with nephrectomy performed in all instead of kidney-sparing procedure. When the highest value of calculated GFR was compared, 28 patients had comparable GFRs (60.87%).

We observed that mGFR (mean) was 11.4 ml/min, cGFR (mean) was 7.42 ml/min, highest calculated GFR was 8.74 ml/min, mGFR < 15 was seen in 27, mGFR 15-30 was seen in 7, mGFR > 30 was seen in 5 and mGFR could not be calculated in 1 patient. Hamed *et al.* [10] had described CT-based renal parenchymal volume assessment using renal arterial phase images to reconstruct a three-dimensional image of the enhancing renal cortex and estimate the renal cortical volume of both sides using volume estimation software. He found a significant correlation between this estimated differential volume and the differential function estimated by DTPA scan in unilateral obstruction. However, this method can only be used in patients with normal creatinine values as it requires contrast enhanced CT images. It also has a higher radiation exposure risk.

In present study we found a strong overall correlation was found between the two methods of GFR estimation. The Gates method, although most commonly used in DTPA/EC scan, is also inaccurate when compared with the plasma sampling method [11]. It tends to underestimate GFR in Stage I and II CKD, and overestimate GFR in stage IV and V CKD. The plasma sampling method itself overestimates GFR as compared to inulin clearance method which has been quantified to be 3.5 ml/min on an average [12].

Conclusion

Authors found that GFR calculated by PCN creatinine clearance can be used for evaluation of residual renal function to assess the management of obstructed kidney when radionuclide scan is not available.

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