Glomerular Filtration Rate by Gamma Camera-Based Method: Interobserver Agreement at a Single Centre

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ABSTRACT

The objective of this study was to determine interobserver agreement (IOA) in the calculation of glomerular filtration rate (GFR) by the gamma camera-based method. It was a cross-sectional prospective study carried out at the Nuclear Medical Centre, the Armed Forces Institute of Pathology, Rawalpindi, Pakistan, from December 2021 to August 2022. A total of 52 patients with a median age of 47.20 years (range = 2-77 years) were included. All the patients underwent technetium-99m diethylene triamine pentaacetate (Tc-99m DTPA) renal scan following a standard protocol, and the scans were processed by the same group of three different observers. The patients were divided into four groups. The intraclass correlation coefficients (ICCs) for interobserver agreement in GFR estimation were as follows: Group 1 = 0.988 (95% CI: 0.971- 0.996), Group 2 = 0.997 (95% CI: 0.990 - 0.999), Group 3 = 0.985 (95% CI: 0.960 - 0.995), and Group 4 = 0.991 (95% CI, 0.976 - 0.996). The present study found excellent agreement among observers in estimating GFR using the gamma camera-based method.

Key Words: *Glomerular filtration rate, Interobserver variability, Intraclass correlation coefficient, Gamma camera imaging ^{99m}Tc-DTPA.*

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Nuclear medicine imaging and reporting involve both detection and quantification tasks. Detection tasks may include identifying certain perfusion defects, skeletal metastases, the presence or absence of cold nodules on thyroid scan and other abnormalities. Quantification tasks involve drawing a region of interest (ROI) to calculate ejection fraction (EF), glomerular filtration rate (GFR), or standardised uptake value (SUV), as performed in positron emission tomography (PET) reporting. Three methods used for drawing ROIs are manual, semi-automatic, and automatic. The least reproducible one is the manually drawn region, as it depends on the observer's intrinsic characteristics. The robustness of the test depends on the degree of interobserver reliability, with results that should be acceptable across various specialities.[1]

The common camera-based method used for the calculation of GFR is Tc-99m DTPA with the Gates formula. The formula requires several inputs including height, weight, renal counts, background counts, pre- and post-injection syringe counts.

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The renal counts are determined by manual drawing of ROI around each kidney, which carries an element of subjective variation. This variation of GFR when calculated by different observers can raise concerns about the standardisation and similarity of reports across centres, necessitating the need for experimental validation. The objective of this study was to determine the extent of interobserver agreement in the determination of total GFR.

The intraclass correlation coefficient (ICC) is used to assess quantitative parameters when more than two observers are involved. The authors used a two-way random-effect ICC (2.k) model as given by Shrout and Fleiss (1979).[2] The interpretation of ICC values was done based on the guidelines by Landis and Kosh.[3]

This prospective study was conducted at the Nuclear Medical Centre, the Armed Forces Institute of Pathology, Rawalpindi, Pakistan, from December 2021 to August 2022. All 52 individuals referred for routine DTPA renal scans were included in the study. Pregnant or lactating females, as well as those with horseshoe and pelvic kidneys, were excluded. The cases fulfilling the selection criteria were selected through non-probability consecutive sampling. A routine renal scan protocol involved administering 100-370 MBq (2.7-10 mCi) of ^{99m}Tc DTPA, followed by posterior imaging, was carried out with a standard procedure. It was followed by a posterior static abdominal image at 30 minutes.

Table I: Classification and rationale for the division of groups.

Groups	Classification of groups	n (%)	Rationale for the classification		Types of ROI
1	Poor functioning	14 (27)	GFR ≥1 and ≤5ml/min on one or both kidneys		Whole kidney
2	Non- functioning	7 (13.46)	GFR = 0 on one or both kidneys		Whole kidney
3	PUJ obstruction	12 (23.07)	Those patients with a referral form indicating diagnosis of unilateral/bilateral PUJ obstruction		Cortical ROI
4	Others	19 (36.5)	Well-functioning kidney	≥40ml/min	Whole kidney
			Fair functioning kidney	≥30ml/min <40ml/min	
			Suboptimal functioning kidney	≥20ml/min <30ml/min	
			Markedly impaired kidney functioning	≥10ml/min <20ml/min	
			Impaired kidney functioning	≥5ml/min <10ml/min	

PUJ: Pelviureteric junction.

Table II: Characteristics of the groups.

Characteristics		Group 1	Group 2	Group 3	Group 4	p-values
Gender (No. of subjects)	Male	11 (78.5%)	4 (57.1%)	8 (66.7%)	13 (68.4%)	0.778
	Female	3 (21.4%)	3 (42.9%)	4 (33.3%)	6 (31.6%)	
Age (years)		**60.50 (34.50)**	40.28 ±26	32.41 ± 21.8	43.42 ± 21.46	0.083
Height (cm)		167 ± 8.26	149.8 ± 26.3	149.6 ± 22.19	**162.7 (14)**	0.074
Weight (Kg)		70 ± 12.2	**59 (49)**	54.5 ± 21.4	68.42 ± 23.7	0.080
BSA (m^2)		1.7 ± 0.191	**1.71 (0.94)**	1.49 ± 0.41	**1.8 (0.2)**	0.071
Total GFR ml/kg (mean ± SD)	Observer 1	47.97 ± 14.6	40.20 ± 29.8	75.77 ± 38.61	66.37 ± 26.92	0.019
	Observer 2	48.51 ± 13.96	40.98 ± 30.9	81.25 ± 40.01	68.04 ± 28.6	0.010
	Observer 3	48.83 ± 12.67	42.8 ± 32.4	80.69 ± 36.8	71.30 ± 28.47	0.007

Note: Bold numbers represent median and interquartile range (IQR) for non-normally distributed data. p-value was calculated for categorical data by the Chi-square test and for continuous data by the ANOVA.

Following the renal scan, each case was seen by the same group of three observers who processed the scan on a gamma camera equipped with ESOFT version software. At 4 minutes, a ROI was manually drawn around each kidney on the spectrum colour scale using the edge detection method. A background ROI for each kidney was automatically generated by the software. The time activity curve was generated, and total and differential GFR normalised to body mass index were calculated by the software using the Gates formula. The formula requires patients' height, weight, and computer-calculated renal depth. After mutual consensus of the observers, the patients were placed in one of the four groups, according to the rationale given in Table I.

A total of 52 patients were included, comprising 36 males (69.2%) and 16 females (30.8%), with ages ranging from 2 to 77 years (median age: 47.20 years). They were divided into four groups: poor functioning, non-functioning, pelviureteric junction (PUJ) obstruction, and others.

Age, gender, weight, height, and body surface area (BSA) did not significantly differ among the three groups (Table II). Interobserver agreement (IOA) for continuous data involving more than two observers was calculated using the ICC (2, k) model. Each observer was unaware of the calculation done by the other observer. The ICC values for group 1,2,3, and 4 were 0.988 (95% CI: 0.971-0.996), 0.997 (95% CI: 0.990-0.999), 0.985 (95% CI: 0.960-0.995), and 0.991 (95% CI: 0.976-0.996), respectively. The overall ICC was 0.991 (95% CI 0.985-0.995). These results showed an excellent interobserver agreement across all the groups.

The current study focused on the determination of the interobserver agreement in the calculation of GFR using the gamma camera-based method. Despite operator-dependent variation linked with the manual drawing of ROIs around each kidney, the consistency in GFR determination across observers depicts the overall reliability of the method. A study by Inoue *et al*. attributed the unpredictability in calculating GFR by manual drawing of ROI to the effect of scatter, the respiration of patients and the delineation of margins of kidney due to reduced peripheral thickness of kidney. He concluded that semi-automated methods provide the best inter-operator reproducibility in the calculation of GFR.[4]

The results of this study were consistent with those of a study carried out in China involving 54 kidneys, which concluded a high correlation between the manual contours of two observers and those obtained by the automated approach. However, some adjustable parameters mentioned in their approach needed further research to reduce these parameters.[5] Wang *et al*. compared renal function estimation using contrast-enhanced MR renography (GFRMR) and renal scintigraphy (GFRRS). They also estimated interobserver reliability among three observers for each method and found good interobserver reliability with ICCs ranging from 0.82 to 0.92 for GFRMR and 0.79 to 0.90 for GFRRS.[6]

The current article determined high concordance among observers, attributed it to the standardised method involving continuous training of observers in drawing ROIs using the edge detection method on the spectrum colour scale, along with the use of automated background ROIs. The study underscores the robustness of the method despite being a single-centre study with operator variability, and it contributes to the continuing discourse on dependable GFR assessment methods, highlighting the practicality of the gamma camera-based method for practical application in clinical settings.

COMPETING INTEREST:

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTION:

RS: Conception of the study, design statistics, and drafting.
ZSD, MA: Acquisition of the data, revision, and intellectual content.

ZS, RF: Revision and intellectual content.

All authors approved the final version of the manuscript to be published.

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