Measurement of Glomerular Filtration Rate (GFR) in an Ectopic Pelvic Kidney by Dual Head Gamma Camera

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ABSTRACT

Background: **DTPA renogram is an accepted method to measure glomerular filtration rate (GFR) of the kidneys. The function of an ectopic kidney varies on the basis of its size, shape, position and rotation. This may lead to variation in tissue attenuation and error in computed GFR and differential renal function (DRF) of each kidney. The objectives of this study was to assess the changes in the GFR measurement of an ectopic kidney in a dual head gamma camera using anterior and posterior imaging process and its influence on quantification of total GFR.**

Patients and Method: **A Total 20 patients having one ectopic pelvic kidney and other normal positioning kidney were enrolled in the study. DTPA renogram images were acquired on a dual head gamma camera (Symbia T2) in anterior and posterior views simultaneously. Both anterior and posterior images data were used separately to compute the GFR. Three sets of total GFR of both kidneys were calculated separately. In set I, total GFR (ant) is equal to sum of both kidneys GFR in anterior imaging process, in set II total GFR (post) is equal to sum of both kidneys GFR in posterior imaging process and in set III total GFR (ectopic .ant + normal. post) is equal to sum of the GFR of normal kidney on posterior image and the GFR of ectopic kidney on anterior image. These three sets of total GFRs were compared with the patient's eGFR measured by Cockcroft Gault formula.**

Result: **Mean age of the patient was 36.9 ± 14.6 years (range 18-70 years). Mean total GFR (ant) was 89.2±11.6 ml/min, total GFR (post) was 82.9±13.4 ml/min and total GFR (ectopic.ant + normal.post) was 102.5±15.9 ml/min. Mean eGFR is 101.93±24.9ml/min. When these three sets of DTPA assisted GFR compare with eGFR the Pearson's correlation coefficient r= 0.45, 0.55 ($P<0.05$) for GFR (ant) and GFR (post) respectively whereas, in case of GFR (ectopic .ant + normal.post) correlation coefficient r= 0.8 ($P<0.01$).**

Conclusion: **The GFR of ectopic kidney as calculated from the anterior data was significantly higher in comparison to the GFR calculated from the posterior data.**

Keywords: **Ectopic Kidney, Glomerular Filtration Rate (GFR), DTPA renogram**

INTRODUCTION

Measurement of GFR is a widely accepted standard method for the assessment of renal function. GFR can be precisely measured by using various filtration markers like inulin clearance, creatinine–cystatin C clearance etc. These procedures are cumbersome, costly and not readily available (1). DTPA renogram is widely used in measuring the GFR in clinical practice. Conventionally the renal dynamic study is done with patient in the supine position and the camera detector is placed posterior to the patient. Post-acquisition processing is done with the posterior image data to generate renogram curves and to compute the GFR, differential renal function (DRF) and other quantitative parameters (2). In case of ectopic kidney the depth and position can vary and this leads variation of quantitative parameters. The objective of this study was to assess the changes in the GFR measurement of an ectopic kidney in a dual head gamma camera using anterior and posterior imaging process and its influence on quantification of total GFR.

PATIENTS AND METHOD

The study included 20 patients having one ectopic pelvic kidney with contralateral normal positioning kidney. They were referred for a DTPA renogram study in Institute of Nuclear Medicine and Allied Science, Mitford from January to December 2016. Renal scintigraphy was performed on a dual head gamma camera (Symbia T2) using standard protocol. Patients were imaged in the supine position with both

camera detectors positioned close to the patient including the kidneys and bladder in the field of view. A bolus dose of 5 mCi ^{99m}Tc-DTPA was administered intravenously. Images were acquired simultaneously both by the anterior and posterior detectors. Thus, two sets of images were acquired simultaneously in anterior and posterior views. Renogram analyses were done separately using both anterior and posterior imaging process. The GFR of the normal positioning kidney and ectopic kidney were noted down from both posterior and the anterior data sets. Three sets of total GFR of both kidneys were calculated separately. In set I total GFR (ant) is equal to sum of both kidneys GFR in anterior imaging process, in set II total GFR (post) is equal to sum of both kidneys GFR in posterior imaging process and in set III total GFR (ectopic .ant + normal.post) is equal to sum of the GFR of normal kidney on posterior image and the GFR of ectopic kidney on anterior image.

Estimated GFR (eGFR) was calculated using Cockcroft Gault formula: (140-age) x Body weight (kg) / 72 x Serum creatinine (mg/dl), in case of female multiply with 0.85.

A comparison was made between the total GFRs calculated by DTPA renogram and the eGFR.

Statistics analysis:

Values are presented as mean±SD. For comparison and agreement analysis of the GFRs Pearson's correlation test was done using SPSS software version 20. P-value of less than 0.05 was considered significant.

RESULTS

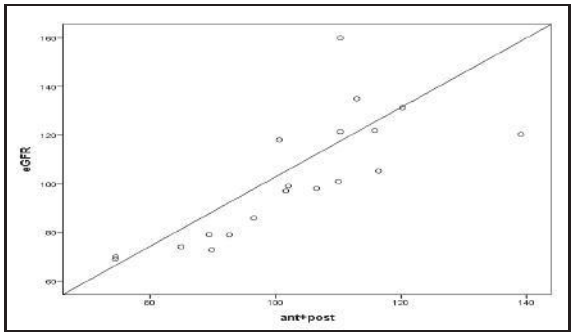
Among 20 patients, 13 were male and 7were female. Mean age of the patient was 36.9 ± 14.6 years (range 18-70 years). Mean GFR of ectopic kidney in interior imaging process was 36.7 ± 8.7 ml/min and in posterior imaging process was 21.8±8.8 ml/min. The mean GFR value on anterior imaging process was significantly higher than the posterior (t=5.38, P<0.001).

Table 1: Comparison of the measured total GFRs (ml/min) of two kidneys between anterior and posterior image processing on renal dynamic imaging and the eGFR

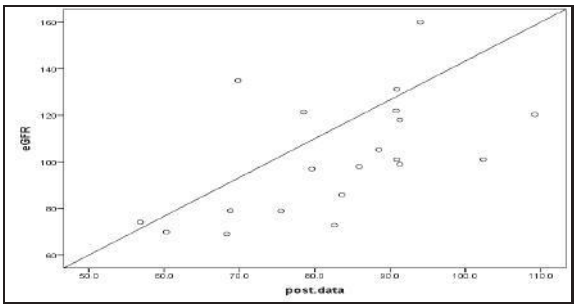
No	Total GFR (ant)	Total GFR (post)	Total GFR (ectopic.ant + normal.post)	eGFR
1.	78.9	91.3	101	118
2.	95.8	88.5	116	105
3.	72.1	90.9	110	101
4.	90.3	79.6	102	97
5.	99.2	78.5	110	121
6.	80.3	68.8	89	79
7.	71.0	56.8	85	74
8.	99.1	75.5	93	79
9.	90.7	69.8	113	135
10.	78.5	91.3	102	99
11.	89.1	68.3	74	69
12.	94.2	82.6	90	73
13.	65.9	60.3	75	70
14.	99.7	85.9	107	89
15.	100.9	94.0	110	160
16.	83.7	83.6	97	86
17.	106.2	102.4	103	101
18.	99.8	109.2	139	120
19.	102.1	90.9	120	131
20.	88.1	90.8	116	122
Mean ±SD	89.2±11.6	82.9 ± 13.4	102.5± 15.9	101.9 ±24.9

Mean total GFR (ant) of both kidneys was 89.2±11.6 ml/min, total GFR (post) was 82.9±13.4 ml/min and total GFR (ectopic.ant + normal.post) was 102.5±15.9 ml/min. Mean eGFR was 101.93±24.9ml/min. When these three sets of DTPA renogram analyzed GFR compared with eGFR the Pearson's correlation coefficient r= 0.45, 0.55 (P<0.05) for GFR (ant) and GFR (post) respectively whereas, in case of GFR (ectopic.ant + normal.post) correlation coefficient r= 0.8 (P<0.01).

a)



b)



c)

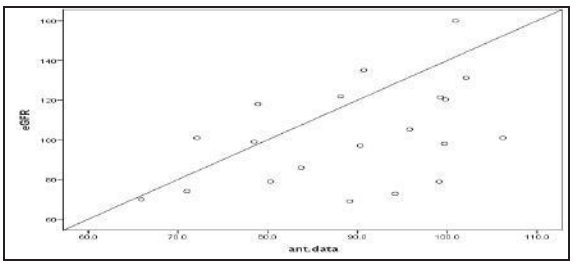


Figure 1: Scatter diagram showing correlation between a. eGFR and GFR (ectopic.ant + normal.post) b. eGFR and GFR (post) c. eGFR and GFR (ant)

DISCUSSION

Ectopic kidney is a condition that may presents in the true pelvis, iliac fossa or in lower lumbar region and occurs because of an embryonic developmental anomaly. Majority of ectopic kidney lies in the pelvis (3, 4). Diagnosis of ectopic pelvic kidney can be made by ultrasonography. Other imaging modalities such as renal cortical scintigraphy using 99mTc dimercaptosuccinic acid, CT, and MRI have been shown to be useful in the diagnosis of ectopic kidney. Generally, no treatment is required for an ectopic kidney if the renal function is normal but ectopic kidney can be complicated by hydronephrosis, urinary tract infection, and calculi (5, 6).

For measurement of total GFR of both kidneys, two-sample methods and serum creatinine–cystatin C clearance determinations are more precise methods but it is cumbersome, costly not widely available. In clinical practice, renal dynamic imaging is widely used for evaluation of renal function. However, it has some drawbacks in terms of the measurement of GFR of kidneys. Interference factors such as proper hydration of patient, 'bolus-like' injection, depth of kidneys, acquisition position may affect the measurements. With other factors remaining unchanged, the position and depth of the kidneys (the distance of the kidneys from the skin of the abdomen and the lumbar region) are two important factors in the measurement of the GFR (7). When the kidneys are located in the usual position, renal depth correction in renal dynamic imaging is achieved using the formula $e^{-\mu x}$ (where μ=0.153, the linear attenuation coefficient for 99mTc radiation in soft tissues, and x=the mid-plane depth of each kidney, in cm, which can be estimated from the patient's height and weight according to the formulae of Tonnesen and colleagues. If there is a 1 cm change in renal depth, the GFR will show a large difference (8). As because the position of an ectopic pelvic kidney is closer to the skin of the abdomen rather than the skin of the lumbar region, the values of its depth estimated in the posterior view will be less accurate for GFR estimation than those estimated in the anterior view . As an ectopic pelvic kidney viewed more clearly in the anterior view than posterior, the region of interest (ROI) of an ectopic kidney can be drawn more easily and the function measured will be more precise in the anterior view. Theoretically, the GFR of an ectopic pelvic kidney measured using Gates' method in the anterior view should be higher than that in the posterior view (8, 9). In the present study, anterior view GFR (36.7±8.7 ml/min) of an ectopic pelvic kidney was significantly greater than GFR (21.8±8.8 ml/min) on posterior view ($t=5.38$, $P<0.001$). Similar findings observed in a study where the mean GFR of the ectopic kidney on anterior image was 27.48±12.24ml/min and on posterior image 10.71±4.74 ml/min ($t=5.481$, $P<0.01$) which is statistically significant (10, 11). This finding is matched with another study done by Gopal SM et.al where, GFR of ectopic kidney using anterior image was significantly higher ($P<0.002$) compare to that calculated by posterior images (2).

Regarding total GFR, in present study mean total GFR (ant) of both kidneys using anterior imaging data was 89.2 ±11.6 ml/min and GFR (post) using posterior imaging data was 82.9±13.4 ml/min. When sum of the

anterior GFR of ectopic kidney and the posterior GFR of contra lateral normal kidney is used mean total GFR (ectopic .ant + normal. post) was 102.5±15.9 ml/min. Comparing these three sets of renogram analyzed GFRs with patient's eGFR the Pearson's correlation coefficient r= 0.45 , 0.55 (P<0.05) for GFR(ant) and GFR(post) respectively whereas, in case of total GFR (ectopic .ant + normal.post) correlation coefficient r= 0.8 (P<0.01).In a similar kind of study done by Deshan where they compare the total DTPA GFR with GFR measured in two-sample method. They concluded that there was better correlation between total GFR in anterior image and GFR in two-sample method (r=0.704, p<0.05) whereas, worse correlation found between total GFR in posterior image and GFR in two-sample method(r=0.576, p>0.05) (10). This findings was matched with the reported results of another study showing better correlation between the total GFR using anterior image and the total GFR measured by two sample method (Z= −2.295, P<0.05) whereas, in case of GFR measured by using posterior image data the result was (Z=−2.191, P<0.05)(11)

As the majority of ectopic pelvic kidneys are located close to urinary bladder, they often overlap with the top portion of the full bladder. Hence, the portion of the ectopic kidney overlapping the bladder will interfere in the construction of ROI of the ectopic kidney in the anterior view which may lead to a variation in measurement of GFR. In this study, 6 out of 20 patients were in this kind of situation. When the overlapping portions of ectopic kidney with the bladder were removed in drawing ectopic kidney ROIs, the ectopic kidney ROI was smaller than its true ROI. In these cases their total DTPA measured GFR became significantly lowers than eGFR.

CONCLUSION

In renal dynamic imaging functional condition of ectopic pelvic kidney can more truly reflect in anterior image than the posterior. In DTPA renogram for measuring total GFR of both kidneys when the person has an ectopic kidney, analysis of both anterior and posterior imaging processes improve the accuracy of measurement and it will help to differentiate a normally functioning ectopic kidney from a poorly functioning one.

REFERENCES

1. Jahan F, Chowdhury MNU, Mahbub T,Arafat SM, Jahan S,Hossain M, Khan MF.Bangladesh Med Res Counc Bull 2013;39:74-79.
2. Gopal SM, Sujata M. Improved quantification of glomerular filtration rate and differential renal function of ectopic kidneys in a dual head gamma camera. OJMI 2014;4:9-12.
3. Krishnaveni CK, Kulkarni R. A right ectopic kidney with bilateral multiple anomalies of the renal vasculature – a case report. J Clin Diagn Res 2013;7:150–153.
4. Taslim BB, Abdulwasiu BA, Olusegun S, Oluwatoyin AC, Omolara MM. Crossed renal ectopia coexisting with nephrolithiasis in a young Nigerian man. Arab J Nephrol Transplant 2012;5:107–110.
5. Kim TH, Lee HH, Lee SH, Yi BH. Three-dimensional CT is useful for diagnosing an ectopic kidney. J Obstet Gynaecol 2010;30:877–878.
6. Lu CC, Tain YL, Yeung KW, Tiao MM. Ectopic pelvic kidney with urinary tract infection presenting as lower abdominal pain in a child. Pediatr Neonatol 2011;52:117–120.
7. Levey AS, Inker LA, Coresh J. GFR estimation: from physiology to public health. Am J Kidney Dis 2014;63:820–834.
8. Tønnesen KH, Munck O, Hald T, Mogensen P, Wolf H. zumWinkel K, Blaufox MD, Funck-Brentano J-L. Influence on the renogram of variation in skin to kidney distance and the clinical importance thereof. Radionuclides in nephrology Proceedings of the 3rd International Symposium. Berlin: Publishing Sciences Group 1975:79–86.
9. Gates GF. Computation of glomerular filtration rate with Tc-99m DTPA: an in-house computer program. J Nucl Med 1984;25:613–618.
10. Deshan Z, Baojun Li. Comparing the difference of measured GFR of ectopic pelvic kidney between anterior and posterior imaging processing in renal dynamic imaging. J Nucl Med 2014;55:28-33.
11. Na Li, Baojun Li, Wenli Liang, Deshan Zhao. Comparison of glomerular filtration rate measured between anterior and posterior image processing using Gates' method in an ectopic pelvic kidney Nucl Med Commun 2016;37:519–524.