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CASE REPORT

An Unusual Case of Horseshoe Kidney: Obstructed Drainage or Not?

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ABSTRACT

Horseshoe kidney is a common congenital anomaly. Complications such as ureteral obstruction, hydronephrosis, recurrent calculi, or infection are common and may require surgical intervention. This report is of a 20-year-old man with known horseshoe kidney. No urinary obstruction in either moiety was detected by technetium-99m–labelled mercaptoacetyltriglycine scintigraphy with diuretic renography performed using posterior acquisition at other hospitals. However, urodynamically significant outflow obstruction in the left moiety was shown on technetium-99m–labelled mercaptoacetyltriglycine study with dual-head acquisition performed subsequently at the Queen Mary Hospital. The diuretic phase of the left moiety based on the anterior views revealed persistent accumulation of radioactive tracer, while the posterior images demonstrated slightly improved drainage in the left moiety after diuretic administration. This patient illustrates an interesting phenomenon of radioactive tracer drainage in a horseshoe kidney. Radioactive tracer usually drains from the posteriorly positioned superior aspect of the kidney to the anteriorly positioned pelvic region. Although the diuretic clearance half-time from the images acquired posteriorly showed improved drainage, there was no improvement in tracer clearance half-time based on the combination of anterior and posterior views. Although diuretic study using posterior acquisition only is useful for differentiating a dilated collecting system from an obstructed urinary system, the result could be misleading for abnormally positioned kidneys. This case illustrates the importance of simultaneous dual-head imaging and the application of the geometric mean in computing diuretic clearance half-time for assessment of renal drainage in an abnormally positioned kidney.

Key Words: *Drainage; Kidney; Radioisotope renography; Technetium Tc99m mertiatide; Ureteral obstruction*

中文摘要

一例罕見馬蹄腎病例：尿路阻塞？

馬慧嫻、何偉然、黃廣權、羅惠明

馬蹄腎的是一種常見的先天性異常，所引發的併發症如輸尿管梗阻、腎積水、復發性結石或尿路感染並不罕見，且可能需要外科手術。本文報告一名有馬蹄腎的20歲男性，他在其他醫院經^{99m}Tc標記的巰乙酰三甘氨酸（^{99m}Tc -MAG3）腎核素動態顯像伴利尿劑腎造影術後視圖，並無發現有尿路梗阻。但病人其後於瑪麗醫院經雙探頭^{99m}Tc -MAG3動態顯像卻發現左腎明顯有尿路流出梗阻。利尿劑

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腎臟攝影的前視圖顯示左腎放射性示踪劑持續累積，但其給予利尿劑後的後視圖卻顯示左邊的尿液排出有改善。這病例反映馬蹄腎病人的放射性示踪劑排出的一個有趣現象。一般來説，放射性示踪劑會由位於後方的腎上端流向位於前方的骨盆區。雖然由後視圖得出的利尿劑清除半衰期提示尿液引流有改善，但結合前視圖影像後卻發現情況未有改善。縱使利尿劑腎造影術的後視圖可將集合系統擴張與泌尿系統梗阻區分開來，但對於腎位置異常的病人來説，後視圖可能會誤導病情。本病例顯示同時使用雙探頭影像及利尿劑清除半衰期的幾何平均數，對於評估腎位置異常的病人的腎臟引流情況相當重要。

INTRODUCTION

Horseshoe kidney is the most common fusion abnormality of the kidney. There are several variations in the basic shape of the horseshoe kidney. In 95% of patients, the kidneys join at the lower pole; rarely, an isthmus connects both upper poles instead. Horseshoe kidney occurs 1 in 400 of the general population with a male-to-female ratio of 2:1.[1] Embryologically, the ascent of the kidneys is arrested by the median fusion of metanephric tissues. In most patients, this is associated with malrotation, convergent axes, and ventral exit of the ureters.[2] The blood supply to the horseshoe kidney is atypical with duplicate, or even triplicate, renal arteries supplying one or both kidneys. The importance of this condition is that the abnormally positioned kidney is more susceptible to injury, prone to obstructive uropathy with a pelvi-ureteric junction obstruction (PUJO), infection, and renal calculi. There is increased risk of malignancy (e.g. Wilms' tumour and transitional cell carcinoma) when compared with the general population.

Ultrasonography (USG), computed tomography, and magnetic resonance imaging can demonstrate the morphology, but not the functional status, of a horseshoe kidney. Renal scintigraphy is a safe and reliable method to assess renal perfusion and function, and to monitor the treatment effect. Addition of a diuretic helps to differentiate between true obstruction and a dilated unobstructed urinary system, for which the treatments will be totally different. Conventionally the imaging acquisition for renal scintigraphy is posterior because of the usual anatomical position of kidneys.

This report highlights the role of dual-head acquisition in dynamic renal diuretic scintigraphy of a hydronephrotic horseshoe kidney. The clinical evaluation, scintigraphic findings, and the current literature are discussed.

CASE REPORT

A 20-year-old man with known horseshoe kidney had left vesicoureteric reflux with left ureteric reimplantation performed at the age of one year. His condition was complicated by left vesicoureteric obstruction. He was managed conservatively with regular follow-up at other hospitals. Diuretic renal scintigraphy was performed yearly with a standard posterior single-head acquisition protocol. The right moiety remained normal, while the left moiety demonstrated decreased function with slow drainage. There was no significant interval change of the renal function differential over the previous 13 years. Recent USG revealed a horseshoe kidney with marked cortical thinning and severe hydronephrosis of the left moiety.

At presentation to the Nuclear Medicine Unit at Queen Mary Hospital in May 2011, in view of the known horseshoe kidney status, dynamic diuretic renal study using dual-head simultaneous acquisition was performed. The patient was well-hydrated and given technetium-99m–labelled mercaptoacetyltriglycine (^{99m}TcMAG3) intravenously. Imaging was performed in the supine position with dual-head simultaneous acquisition of both anterior and posterior images. Data were acquired using low-energy high-resolution collimator flow images at 1 sec/frame for 1 minute with 64 x 64 matrix size. Dynamic images of 20 sec/frame were obtained for the next 20 minutes. Furosemide 40 mg was injected intravenously with additional dynamic anterior and posterior imaging for 15 minutes. There was no catheterization of the bladder and the patient was asked to ambulate and empty the bladder before the post-void image was taken. The post-micturition views were taken in the erect position. The last frame of the furosemide image was considered the pre-micturition image. Quantitation was not affected as the geometric mean calculation was used.

The scintigraphy study showed the normal size and normal tracer uptake of right moiety. Perfusion, extraction, and clearance of MAG3 from the hydronephrotic left moiety were decreased on both anterior and posterior images. There was persistent abnormal retention of tracer in the left collecting system (Figure 1). There was no abrupt tapering or hold-up of tracer in the left ureter to suggest the site of obstruction. There was no apparent reflux in either kidney detected in the dynamic images. The differential renal function for the left and right moieties was 36%:64% calculated by the geometric mean method (Appendix). On diuretic challenge, slightly improved drainage in the left moiety was clearly demonstrated on the posterior view, with a diuretic clearance half-time ($T_{1/2}$) of 18 minutes (Figures 2a and 3a). Interestingly, the anterior view showed a continuously rising renal curve after furosemide administration, with progressive accumulation and retention of tracer in the left moiety and its collecting system (Figures 2b and 3b). This finding signified an obstruction in the left moiety on the anterior view that contradicted the result of improved drainage on the posterior view.

There was rapid clearance of tracer from the left collecting system after ambulation and voiding on the anterior view (Figure 4a). However, the post-void image on the posterior view demonstrated progressive accumulation of renal activity (Figure 4b).

The authors postulated that the apparent partial emptying activity from the left moiety on the posterior view was an artefact due to the movement of tracer

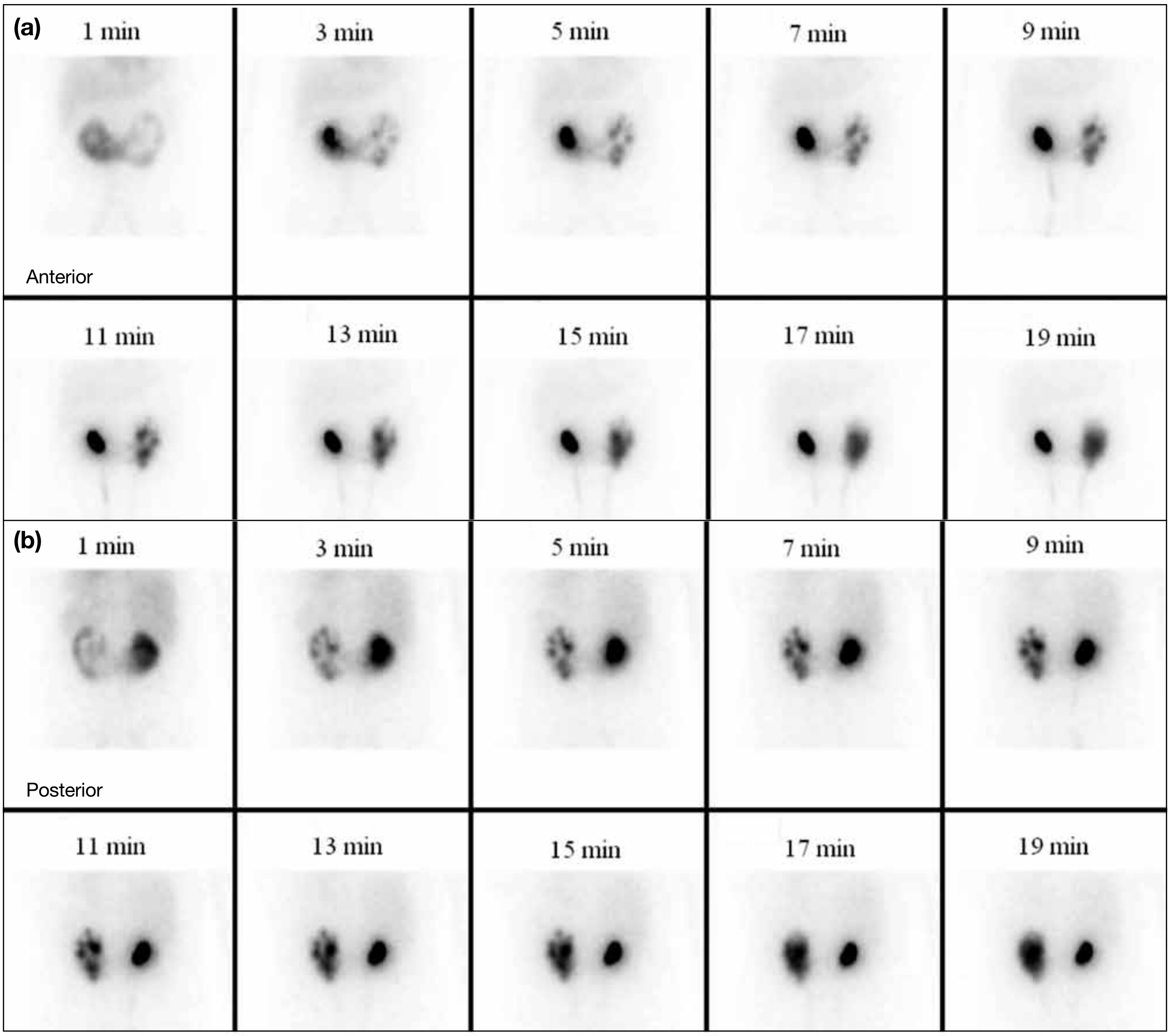

Figure 1. Dynamic (a) anterior and (b) posterior images demonstrating asymmetrical decreased perfusion and function of the left moiety.

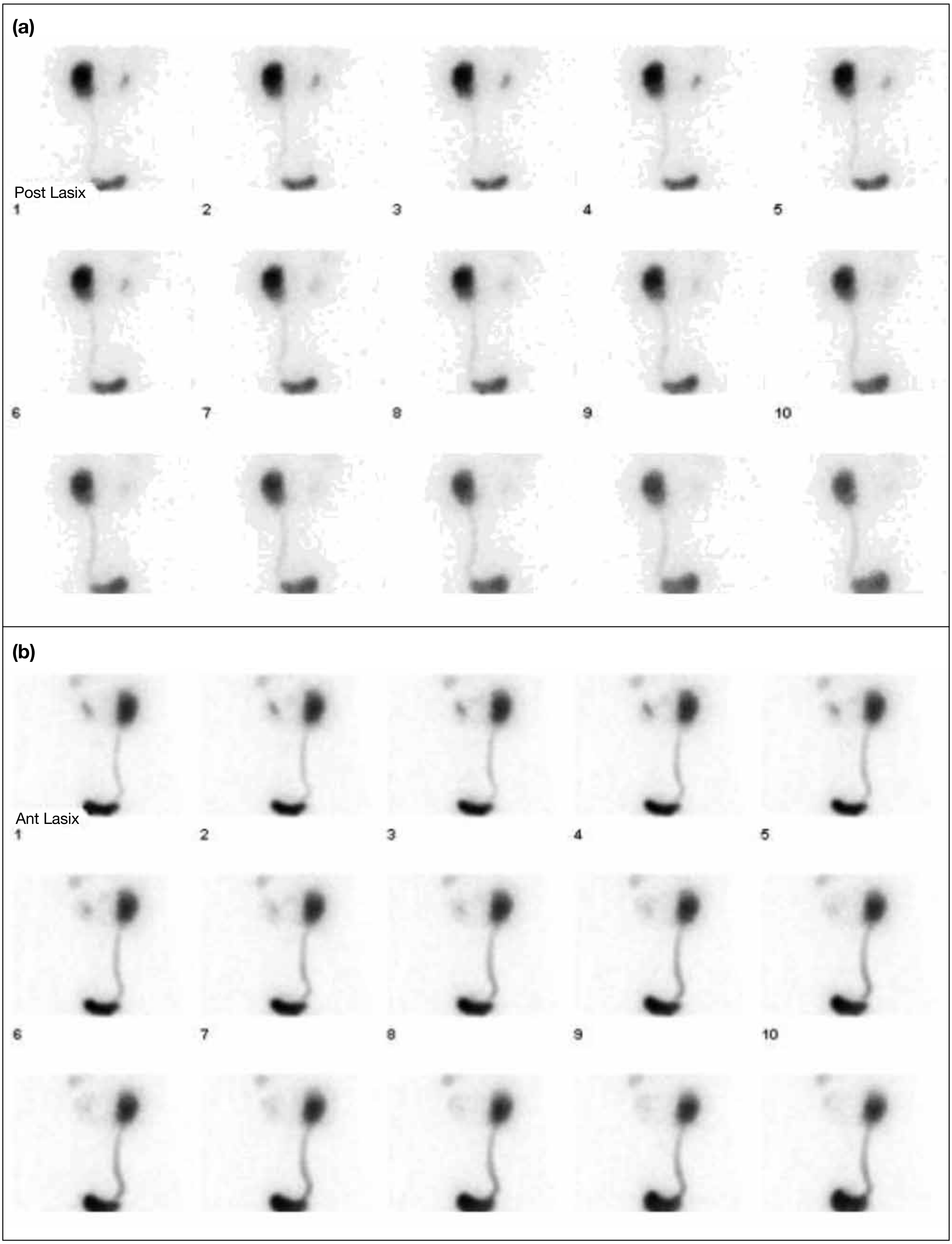

Figure 2. Dynamic diuretic (a) posterior images demonstrating improved drainage and (b) anterior images demonstrating gradual accumulation of radioactive tracer in the left collecting system.

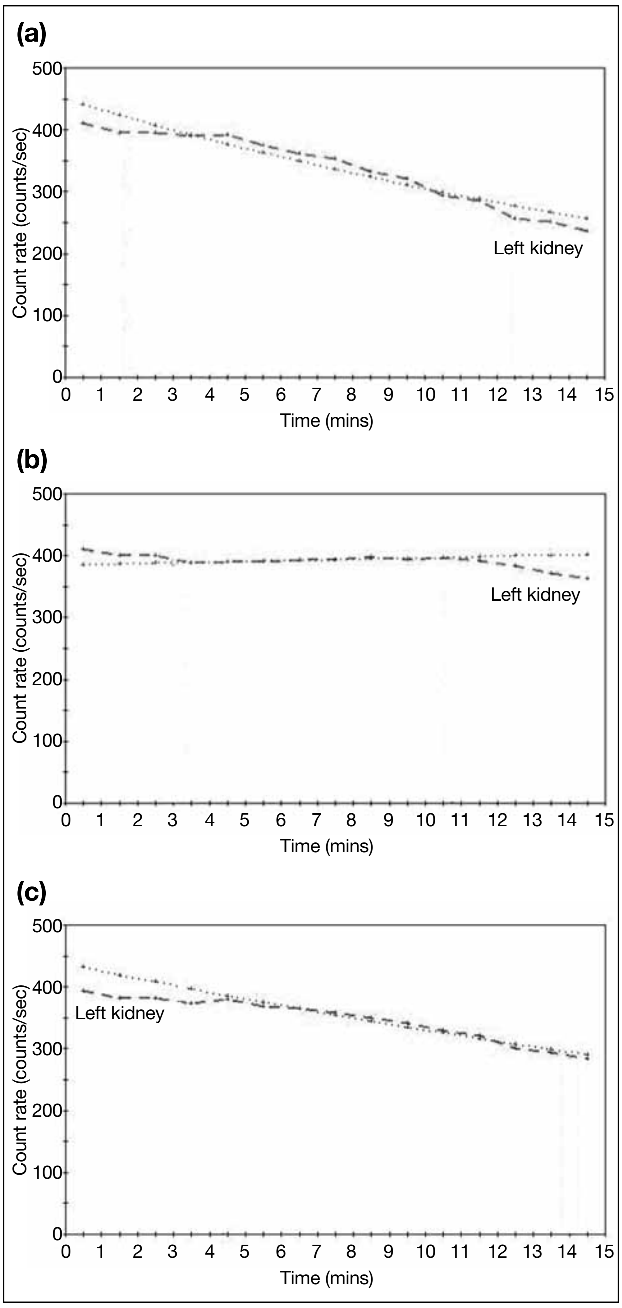

Figure 3. Technetium-99m–labelled mercaptoacetyltriglycine diuretic renogram showing (a) decreased tracer activity in the left moiety and the collecting system in posterior view; the straight line was the linear fit to the time activity curve to obtain diuretic clearance half-time = 18 minutes, (b) the diuretic curve for the anterior view, and (c) diuretic clearance half-time = 71.8 minutes, obtained by the geometric mean method.

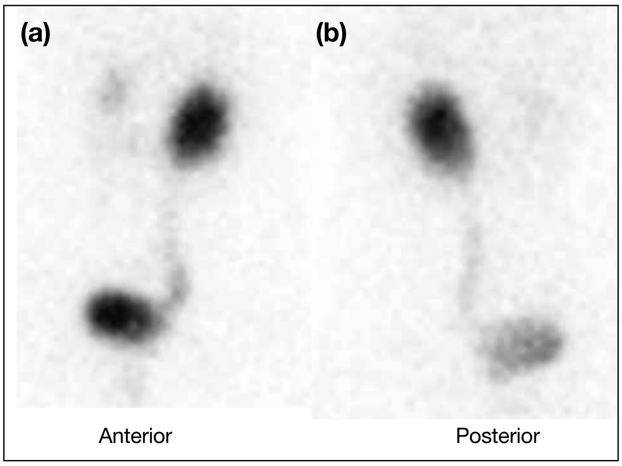

Figure 4. Anterior and posterior postvoid images.

from the posteriorly positioned upper pole to the more anteriorly positioned lower pole during the diuretic phase. In addition, there was non-uniform activity of tracer in the newly formed urine, with lower activity from the posteriorly located calyx to the more anteriorly located renal pelvis on the pre-void image. The post-void image showed uniform mixing of tracer. Hence, there seemed to be accumulation of tracer in the left collecting system on the posterior view after voiding. Taking into account both the anterior and posterior imaging data and the geometric mean calculation of $T_{1/2}$ (Figure 3c), the authors concluded that there was a functionally significant urinary outflow obstruction based on this scintigraphic finding.

DISCUSSION

Often a horseshoe kidney is found incidentally. Approximately 50% of patients with horseshoe kidneys remain asymptomatic.[3] Horseshoe kidney is frequently found in association with other congenital anomalies, with increased occurrence of chronic infection, stone formation, and PUJO causing significant hydronephrosis. Renal scintigraphy is well-established for estimating renal clearance and excretory function; it is sensitive, but non-specific, for obstruction. Furosemide is a loop diuretic that inhibits reabsorption of sodium and chloride in the ascending limb of the loop of Henle, and the proximal and distal tubules. This results in an increase in urinary flow, increased washout of tracer activity from the dilated collecting system, and distinguished functionally significant hydronephrosis. Following diuretic challenge, a region of interest was drawn around the dilated collecting system. Drainage was assessed visually and quantitatively as the response to furosemide (defined as the time for the renal curve to fall to 50% of the maximum value), response to bladder emptying, and change of posture after furosemide administration (post-micturition). Despite the controversy that many factors might influence the interpretation of diuretic renography, e.g. state of hydration, volume of dilated pelvis, bladder catheterization, dose of furosemide, poor renal function, and different methodology of $T_{1/2}$ calculation, it remains a non-invasive and well-accepted imaging test for investigating a dilated urinary system and to assess drainage.

For this patient, the diagnostic challenge was to identify whether there was any functionally significant drainage obstruction in the horseshoe kidney. The suspicion of obstruction in the left moiety was low based on previous MAG3 reports from other imaging centres. However, these scintigraphic findings were based on a conventional posterior acquisition protocol, that is, imaging with the patient lying supine on the imaging table with the camera under the table viewing the kidney and bladder. This protocol assumes that the normally positioned kidneys are nearest to the camera and produces the least attenuation, which depends on the thickness of the soft tissue from the kidneys to the detector. For pelvic or asymmetrical kidneys, anterior images are helpful to demonstrate functioning tissue that may not be apparent on posterior images owing to attenuation. Second, anterior imaging avoids the effect of depth differences in calculating the split function and diuretic $T_{1/2}$. Calculation of the geometric mean represents a relatively simple means to overcome the problems of attenuation.[4,5]

For this patient, the relative renal function and diuretic $T_{1/2}$ obtained posteriorly suggested improved drainage in the left moiety but, after applying the geometric mean method, the opposite conclusion was derived. However, it is not necessary to obtain anterior views for every patient, as there is no additional benefit if both kidneys lie at the same depth.[6] Processing to combine and compute two sets of imaging data will be more time consuming. Furthermore, routine posterior positioning allows standardisation of the procedure and comparison of results between different institutions.

CONCLUSION

At present, the usual application of renography is for measurement of renal uptake function, drainage at presentation, and during conservative treatment or postoperative follow-up. Renal scintigraphy can be used as a guide to monitor for interval change of the differential renal function, hence, to assess the risk of further renal function deterioration. In horseshoe or ectopic kidney, renal function may be under- or over-estimated. These authors recommend the use of a dual-head γ camera with simultaneous dynamic renography acquisition and the geometric mean method for patients with ectopic or horseshoe kidney[7] to enable better evaluation of renal function.

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Appendix. Brief description of the geometric mean method in renal scintigraphy.

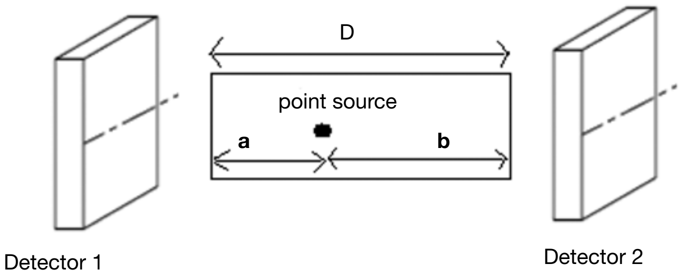

Figure A1. Radioactive source and detectors for the geometric mean method.

Figure A1 shows the arrangement of a radioactive source and detectors for the geometric mean method used in renal scintigraphy.

The attenuation of photons directed towards detector 1 is given by

$$I_1 = I_{01}(e^{-\mu a}) \quad \text{(A1)}$$

Similarly, the attenuation of photons directed towards detector 2 is given by

$$I_2 = I_{02}(e^{-\mu b}) \quad \text{(A2)}$$

where μ is the attenuation coefficient and a and b are source depths. The unattenuated counts I_{01} and I_{02} are detected by detectors 1 and 2, respectively. The total tissue thickness D is given by the sum of depths a and b.

The geometric mean, I_G, is defined as the square root between the product of I_1 and I_2 as

$$I_G = \sqrt{I_1 x I_2} \quad \text{(A3)}$$

Therefore, by taking geometric mean between I_1 and I_2, I_G becomes

$$I_G = \sqrt{I_{01} x I_{02} e^{-\mu(a+b)}} \quad \text{(A4)}$$

Using equation (A3), it is assumed that the photon intensity, I_0, emitted by the tissue is given by

$$I_0 = I_{01} = I_{02} \quad \text{(A5)}$$

$$\sqrt{I_1 x I_2} = \sqrt{I_{01} x I_{02} e^{-\mu D}} \quad \text{(A6)}$$

$$\sqrt{I_1 x I_2} = I_0 e^{-\mu \frac{D}{2}} \quad \text{(A7)}$$

The geometric mean of counts of I_1 and I_2 as detected by conjugate detectors depends on the total tissue thickness D, but not on the source depths of a and b. With the geometric mean method, the variation due to depth is therefore eliminated. However, this method assumes a point source of radioactivity. In a clinical situation, the kidney is an extend source. Therefore, the result obtained with the geometric mean method is only an approximation in renal scintigraphy.