

Effectiveness of Nuclear Scan 99mTc-DTPA in the Evaluation of Renal Function

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Abstract:

Kidney plays a vital role in the elimination of wastes and keeps balance amongst different chemicals, hormones, and blood pressure (hemostasis). With the development and introduction of newly sophisticated ultrasound modalities, it is easy to examine the morphology and hemodynamics of the kidney. But for the estimation of the accurate function of kidney and clearance of wastes products, it is needed to exploit the radioactive nature of radionuclide 99mTc-DTPA. Early diagnosis of renal function is important for the underlying management, we, therefore, used radionuclide scan which is rarely used in the modern era for the function of the kidney. We present the case for the purpose of awareness, development of knowledge and elucidation of the importance of 99mTc-DTPA (diethylenetriaminepentaacetic acid).

Objective:

To diagnose renal function with the help of nuclear scintigraphy.

Case presentation:

This is a case report of a 23-year-old male patient. The patient was presented with a history of right and left lumbar region pain, nausea, vomiting, and painful micturition, incomplete voiding and fever. Value of Glomerular Filtration Rate (GFR) for the left kidney was 4.3ml/min and for Right kidney, GFR was 40.6 ml/min, total GFR 44.9 ml/min (Normal 80-120 ml/min).

Conclusions:

For renal structural abnormalities ultrasound is a better modality while for assessment of renal function & functional abnormalities nuclear scintigraphy is the modality of choice.

Keywords:

Nuclear scintigraphy, Glomerular Filtration Rate (GFR), Hydronephrosis, 99mTc-DTPA (diethylenetriaminepentaacetic acid).

Introduction:

The kidneys are two bean-shaped organs and play important functions in the extraction of waste from blood, balance body fluids, form urine, etc.^{1, 2} With the development and introduction of newly sophisticated ultrasound modalities, it is easy to examine the morphology and hemodynamics of the kidney.^{3, 4} But for the estimation of the accurate function of kidney and clearance of wastes products, it is needed to exploit the radioactive nature of radionuclide 99mTc-DTPA.⁵ Early diagnosis of renal function is important for the underlying management, we therefore used radionuclide scan which is rarely used in the modern era for function of the kidney.⁶ The case was presented for the purpose of awareness, development of knowledge and elucidation of the importance of 99mTc-DTPA.⁷ The comparison of the right and left kidneys shows that the difference in GFR result shows, the function of which of the kidney is grossly impaired.⁸

Kidneys lie retroperitoneally in the gutters of posterior abdominal wall obliquely at the level of the T12 to L3 vertebral bodies. The kidney has been divided into 3 regions that is renal medulla, renal cortex and renal pelvis). Nephrons are the functional unit of the kidney and are 0.8 - 1.5 million in each kidney.⁹⁻¹¹ Renal functions are to retain homeostasis, acid-base, blood pressure and balance in electrolytes and fluid present in the blood. Kidneys functions as a filter for blood

in order to eliminate nitrogenous waste (such as urea, creatinine and ammonia) from our body by the procedure of urination. GFR is the rate at which the blood is filtered by glomeruli. The average reference value of GFR is 120 ml/minute.¹²⁻¹⁴

When blockage or obstruction of urine occurs (urine not drained into bladder properly) the build-up of urine causes swelling of the kidney which is termed as hydronephrosis. Hydronephrosis could be initiated by a different primary diseases or other risk factor such as Congenital blockage, kidney, stone scarring of tissue, Blood clot, Tumor or cancer, Pregnancy and Enlarged prostate (noncancerous).¹⁵

For gross structural pathologies, ultrasound is the modality of choice hydronephrosis is also detected by ultrasound. Sonographic appearance of hydronephrosis is high anechoic areas (no echoes determined by black color on an ultrasound) seen in middle of kidney. In the middle of kidney average anechoic area (the hilum) is interchanged by high hydronephrotic renal pelvis (further studies discovered the position of the obstruction).¹⁶

In nuclear scintigraphy of kidney, images are made by the delivery of radio nucleotide (^{99m}Tc-DTPA) into the kidneys via the bloodstream & excretion of nitrogenous wastes from kidneys through the ureter and filling of the bladder. Assessment of hydronephrosis (a structural pathology) is easy on ultrasound but physiology of kidneys cannot be assessed by it, as grayscale ultrasound is sufficient for structural pathologies only, nuclear renal scintigraphy was used to see the physiology of the organs and to get a deep understanding of the problem.^{16, 17}

Case Presentation:

A patient is 23-years old male who has a history of right and left lumbar region pain, nausea, vomiting and pain with micturition, incomplete voiding and fever.

Ultrasound is a first line diagnostic tool on ultrasound we found that right kidney shows mild hydronephrosis and small hydroureter. While left kidney seems to be normal. For further assessment of the physiology of organ & to investigate underlying cause of disease, we performed nuclear scintigraphy. After the ultrasound, nuclear scan was performed. The scan was performed immediately after an intravenous injection of 250 Mega Becquerel (Mbp) () of ^{99m}Tc DTPA with the patient under the gamma camera in posterior projection till 30 min. Fifteen minutes after the injection of ^{99m}Tc DTPA intra-venous furosemide was injected this makes the filtration of blood fast through kidneys & our scan time is reduced. There are three phases of nuclear scintigraphy for renal imaging uptake vascular phase (flow study), parenchymal phase (uptake), and secretory phase (washout phase). After the commencement of the study and the results show left kidney is poorly visualized without uptake of radiopharmaceutical throughout the study (almost non-functioning).¹⁸ On renogram uptake of the right kidney was good, homogenous (by renal cortical tissue) & good perfusion. There was a good cortical clearance of tracer and activity is seen collecting in the renal pelvis. Renogram graph for a left kidney was horizontal which was showing no minimal function or no function at all. Sonographic findings of the right kidney were hydronephrosis but left was normal (Figure 1). Meanwhile on nuclear scintigraphy, right kidney showed normal function (uptake, perfusion, secretion) even with hydronephrosis (as grayscale sonographic features). The left kidney was normal on ultrasound but on renogram (nuclear scintigraphy) it shows poor function. Nuclear scan reported functional Division of kidneys as right kidney (90 %) and left kidney (10 %), GFR for Right (40.6ml/min) and GFR for left kidney (4.3ml/min). Total GFR of this case was 44.9 ml/min (Normal 80-120 ml/min) (Figure: 2-4).

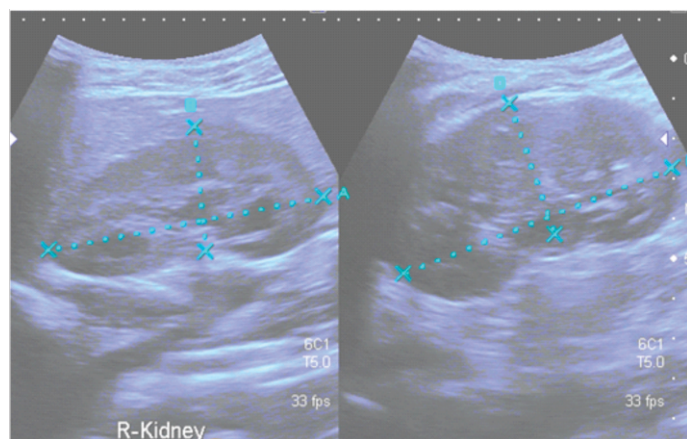


Figure 1: Ultrasound image shows mild hydronephrosis in the right kidney with prominent pyramids

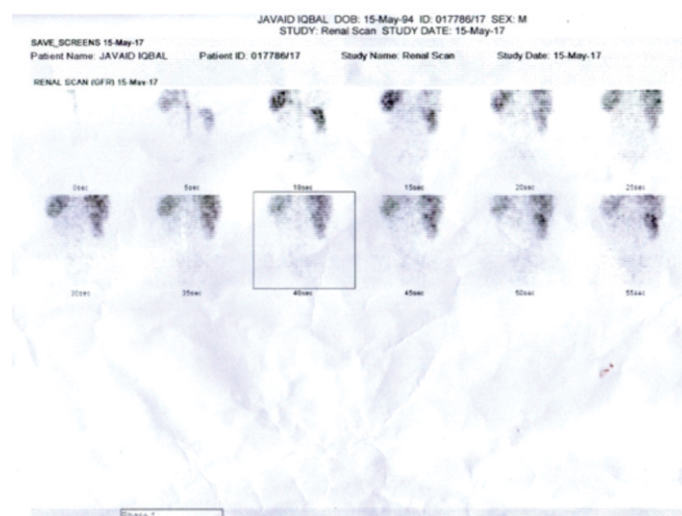


Figure 2: 99mTc-DTPA Renal scan phase I. Flow study, representing renal perfusion. Left kidney is nonfunctioning didn't take radionuclide.

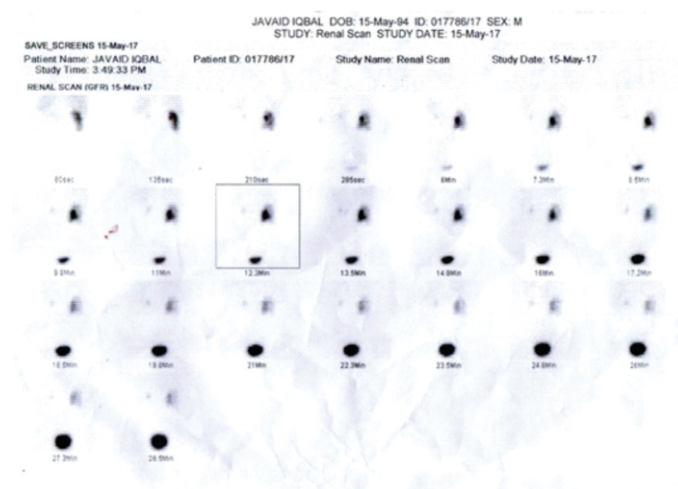


Figure 3: Renal scan phase II

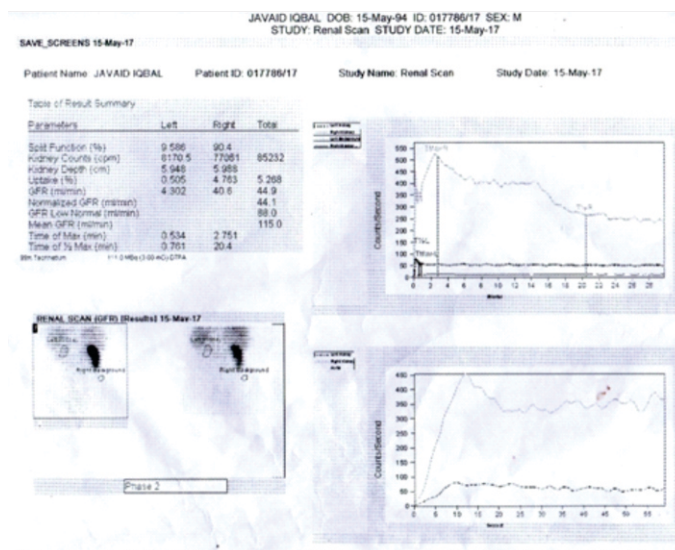


Figure 4: Renogram shows GFR of right and left kidney

Discussion:

Technetium-99m radiopharmaceutical has biological properties similar to o-iodohippuric acid (OIH) and is expected to find wide clinical application for renal function studies. Therefore, it is important to make a kit formulation available which provides reproducibly the desired product in high radiochemical yields. Yapar AF *et al.*, retrospectively studied eight hundred and ninety-one scans of 99mTc Di Mersapto Succinic Acid (DMSA) scintigraphy, to determine age-related difference between Relative Renal Function (RRF). They found significant difference in RRF with age with a p-value smaller than 0.05. It was concluded that a significant difference was found in RRF with renal pathologies and difference in age.⁵

According to a report of National Kidney Foundation Practice Guidelines for Chronic Kidney Disease, it was concluded that in disease and health, GFR is the best parameter for complete renal function. With the variation of sex, age and body size the average, GFR levels varies. In young adults average GFR is about 120 to 130 mL/min per 1.73 m² that drops down with age. A GFR level less than 60 mL/min per 1.73 m² represents a loss of half or more of the adult level

of normal kidney function. It has been proven information that less than this level, the frequency of chronic renal diseases complications elevates. Our case report subject had a GFR of 44.9ml/min which indicates that his renal function has significantly worsened. The divided function of the right and left kidneys shows that the GFR of the right kidney was 40.6ml/min while left kidney was 4.3ml/min. this result shows that the function of the right kidney was grossly impaired as compared to left kidney.¹⁹

According to research published by Anthony W. Murray, a valuable clinical methodology is provided by GFR assessment for renal function quantification. Reference series are usually based on normalized-BSA GFR. The GFR reference series is elevated to this GFR series around the first two years after being born.

Measurements of GFR are void when this is less than about 30 mL/min/1.73 m² or when the patient is older than three months because functional and structural maturation of kidneys are taking place.²⁰

While making urological decision, kidney function is an essential parameter. Individual kidney function is determined by nuclear kidney scanning, that is considered for the calculation of the specific function by using imaging modality. It has a number of benefits. This method is easy, feasible and safe for such type of assessment regardless of these benefits; other different anatomical modalities cannot be given out that are necessary to identify the therapeutic levels. Clearance of creatinine (24 hours) assess the whole kidney function, however, the main drawback of this technique is that it provides an imprint on the complete GFR which makes it incapable to evaluate the separate kidney function that is necessary for obstructed units management.²¹

Conclusions:

Ultrasound can detect the anatomical details and hemodynamics of the kidney, however, 99mTc-DTPA renal scan provides information about the renal function. It is therefore, recommended to use both the modalities in integration with each

other for better results.

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