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A Correlation Study of the Effectiveness of Renal Scintigraphy and Sonography in the Detection and Evaluation of Renal Disorders

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Abstract

Purpose: To evaluate the amalgamation of scintigraphy and sonography techniques in prognosticating renal disease. **Methods:** All the patients were subjected to renal scintigraphy while 68 patients underwent renal ultrasonography. Ninety-six patients' imaging data was statistically analyzed including 43 females and 53 males. Renal U/S reported anatomical renal anomaly in 94.1% of patients versus 85.4% detected by scintigraphy. There were 41 patients out of 68 diagnosed with hydronephrosis and 21 of them were suffering from mild hydronephrosis as suggested by U/S imaging. The data were statistically analyzed using SPSS 21 software. **Results:** Renal scintigraphy of 41 hydronephrotic patients validated that 19 patients had non-obstructive bilateral pelvic dilation while the remaining 22 with mild to severe obstruction. Ultrasonography diagnosed 4 patients with renal obstruction. Conversely, renal scintigraphy validated 2 of them with renal obstruction based on renal function. **Conclusions:** Renal scintigraphy is not significant in diagnosing kidney disease; rather this is a vibrant imaging tool providing supplementary data based on renal function. An effectively targeted intervention regime can be achieved by correlating renal scintigraphy and renal ultrasonography results to minimize renal disease incidence.

Keywords

Renal Disorders, Renal Scintigraphy, Sonography

1. Introduction

Renal diseases affect more than 750 million people globally [1]. Insufficiency in both public awareness campaigns and diagnostic services especially in underdeveloped need to be strengthened [2] [3].

Ultrasound is widely a method of choice to diagnose anatomical urinary system malformations in past decades [4] [5]. Likewise, the scintigraphy technique is a method of choice to understand both functional and structural aspects of renal abnormalities [6].

However, there is a deficit of published literature citing effective targeted intervention involving these two methods for renal diseases. Therefore, the present retrospective survey is essential to evaluate the amalgamation of scintigraphy and sonography techniques in prognosticating renal disease.

2. Materials and Methods

This retrospective survey was accepted by the Medical Ethical Review Committee of the King Abdulaziz University Hospital. It declared that the current descriptive retrospective study jurisdiction does not fall under the Law on Medical Biosafety Research. Data records of 100 patients who underwent renal scintigraphy and renal ultrasonography at the King Abdulaziz University Hospital from 2014 to 2019 were collected. Patients with age 18 years or more and suffering from any renal disease (excluding renal cancer) were included in the study.

Renal ultrasonography was performed by a radiologist using a transducer using a convex array transducer of 2.5 - 5 MHz. All the patients were requested to drink a sufficient volume of fluid 1 hour before the renal sonography. An anterolateral kidneys scan was performed as the patient exposed abdomen lying in the supine position. For each kidney, transverse and anteroposterior dimensions were measured along with parenchymal thickness, presence of renal stones, and dilation of the renal pelvis were recorded. An anomaly about parenchymal echogenicity, hydronephrosis, or anatomic renal malformations including a small-sized kidney, non-visualized kidney, double collecting system along with impaired corticomedullary distinction or enlarged urinary bladder was taken into account.

Patients were asked for intravenous fluid intake 30 to 60 minutes before injection and to lie in the supine position for renal scintigraphy. The patients were suggested to keep a distance of 2 to 3 meters from other people for 24 hours after completion of the procedure. The radioisotope used for this study was Technetium Tc-99m chelated with radiopharmaceutical drug Diethylenetriamine Penta acetic Acid (DTPA). Patients were administered intravenously maximal dose of 5 millicurie Tc-99mDTPA. A high-resolution gamma camera interfaced to a digital computer was used to capture radiations emitted by radioisotope and signals were converted into electronic form to generate the 2D result. Dynamic images were obtained for 1 minute followed by injection of furosemide with subsequent dynamic images for 20 to 30 minutes. Time-activity curves were generated based on regions of interest related to the digital images of the kidney. Renal malformations diagnosed through scintigraphy were explained in the form of delayed tracer handling, split renal function of more than 10% between kidneys, renal scarring, functional size of kidneys, abnormal renogram, and anatomic

renal disorders including small kidney, non-visualized kidney, double collecting system, and horseshoe kidneys.

The radiologist and nuclear physician were unaware of the outcomes of ultrasonography and scintigraphy respectively. The data were statistically analyzed using SPSS 21 software.

3. Results

According to the inclusion criteria, 96 patients were recruited who were suffering from different types of kidney disease. There were 53 males and 43 females.

The following section gives the demographic variable of the participants included in the research study (N = 96), thus including the description of means, standard deviation, and frequencies of their Age and Gender.

The mean age of the participants was 44.3 with an SD of 4.09. On the other hand, the mean Gender of Participants is 1.6 with an SD of 0.13. Whereas, the mode is the most repeated value in the data, which is 49 in case of age and 2 in case of gender (2 for males and 1 for females) (Table 1).

Table 2 described the correlation between Age and Gender of the patients with Genitourinary Disorder. The results exhibited that there is no significant difference in correlation between age and gender of the participants with Genitourinary System Disorder.

Table 3 described the correlation between Age, Gender, and Scintigraphy of patients with Genitourinary System Disorder. The result of the analysis revealed that there was a significant but negative relationship between age and the scintigraphy of the patients.

Table 4 described the correlation between Age, Gender, and ultrasonography of patients with Genitourinary System Disorder. The result revealed that there was a significant but negative relationship between age and ultrasonography of the patients with genitourinary system disorder.

Table 1. Mean and standard deviation of demographic variables of participants (N = 96).

Variable	M	SD	Mode
Age	44.3	4.09	49
Gender	1.6	0.13	2

Note: M = Mean, SD = Standard Deviation, M = Mode.

Table 2. Summary of intercorrelations, for age and gender on genitourinary system disorder (N = 96).

Factor	1	2
1) Age	1	-
2) Gender	−0.23 (ns)	1

Note: ***p < 0.001, **p < 0.01, *p < 0.05, p > 0.05, ns = non significant.

Table 3. Summary of intercorrelations, for age, gender and scintigraphy on genitourinary system disorder (N = 96).

Factor	1	2	3
1) Age	1	-	-
2) Gender	−0.23 (ns)	1	-
3) Scintigraphy	−0.03*	0.11 (ns)	1

Note: ***p < 0.001, **p < 0.01, *p < 0.05, p > 0.05, ns = non significant.

Table 4. Summary of intercorrelations among age, gender and ultrasonography on patients with genitourinary system disorder (N = 96).

Factor	1	2	3
1) Age	1	-	-
2) Gender	−0.23 (ns)	1	-
3) Ultrasonography	−0.00***	0.07 (ns)	1

Note: ***p < 0.001, **p < 0.01, *p < 0.05, p > 0.05, ns = non significant.

All the patients underwent renal scintigraphy while ultrasonography was performed on 68 patients. The most prevalent clinical manifestation was hydronephrosis and renal obstruction. Through ultrasonography, 41 patients were diagnosed with hydronephrosis out of 68. In the case of renal scintigraphy, 19 patients were diagnosed with hydronephrosis out of 96. On the other hand, post-void/pre-void residual volume was determined in 15 patients through ultrasonography. The renal US was found to be abnormal in diagnosing different renal diseases in 64 patients with a sensitivity of 94% while renal scintigraphy identified 82 patients with different renal diseases with an approximate sensitivity of 85%. In renal ultrasonography, 4 patients were diagnosed with no renal disease out of 68 while in the case of renal scintigraphy it was 14 out of 96.

There were 4 patients reported with renal obstruction in ultrasonography out of 68 while renal scintigraphy diagnosed 2 of these 4 with renal obstruction based on renal function.

Pre-void/post-void residual urine volume was determined in 15 patients through U/S and 3 patients reflected abnormality in their post-void residual urine volume which was more than 80 ml. In total, 19 out of 96 renal disease patients were diagnosed with renal obstruction through renal scintigraphy.

4. Discussion

Renal disease is a universal threat distressing 750 million people globally and can cause complications like chronic kidney disease, hypertension, acute kidney injuries, proteinuria, and kidney scarring [1] [7]. The ultimate purpose of the cure is to prevent or decrease the complications of kidney disease. For a normal adult, approximated blood flow is 500 mL/min per kidney which is nearly 20% of cardiac output with a blood volume of 50 ml/kidney having 300 - 350 mL/min/100g

renal perfusion. In a healthy human, the Glomerular filtration rate (GFR) is 50 - 60 mL/min per kidney and renal plasma flow (RPF) is 250 - 300 mL/min per kidney having a filtration fraction (GFR/RPF) of 0.2. Aging results in the decline of kidney function at an approximate rate of 1 mL/min per year from age 40 years to ahead. Women experience a quicker rate of decline when compared to men regarding this aging parameter [8].

Accurate diagnosis of kidney disease proves bottleneck solely based on clinical and laboratory tests. Many imaging techniques have been reported based on their comparison and correlation studies to diagnose precisely renal malformations. For this purpose, ultrasonography is routinely practiced [9]. Voiding cystourethrography (VCUG) is recommended if ultrasonography diagnoses scarring, hydronephrosis, or other findings suggestive of obstructive uropathy or vesicoureteral reflux [10]. A renal scintigraphy scan is a preferred diagnostic test to estimate GFR and blood flow in kidneys [11]. In most cases, renal US is effective to identify urinary tract abnormalities but is not prioritized for renal parenchymal diagnosis [12].

The current study included 96 renal disease patients with 43 females and 53 females. All the patients underwent renal scintigraphy but 68 of them experienced U/S imaging procedure. The most commonly diagnosed manifestations were hydronephrosis and renal obstructions. Our results identified 41 patients out of 68 diagnosed with hydronephrosis through U/S imaging and 21 of them were suffering from mild hydronephrosis. Ultrasound is a non-specific but sensitive and easy repeatability method to detect hydronephrosis due to its non-invasive nature. Such summarizing results show that there is the possibility of differing levels of obstruction. The major diagnostic constraint of ultrasound is its failure to specify functional details. Ultrasound captures static images of urinary systems that do not provide functional information [13] [14] [15] [16].

Relative kidney function can be quantified through radionuclide imaging and tubular agents are preferred to quantify relative kidney function and measure renal blood flow because of their efficient single transit excretion through renal arterial blood of the kidney [17] [18]. Radiopharmaceutical Tc-99m-DTPA mixes in blood insignificantly binding with the plasma proteins and do not infiltrate red cells. Tc-99m-DTPA is the small hydrophilic molecule that crosses capillary endothelium by employing a passive diffusion mechanism ultimately distributing throughout the extracellular fluid volume. Renal scintigraphy GFR corresponds very well to 24-hour creatinine clearance because of extreme reproducibility throughTc99m-DTPA renograms and Glomerular Filtration Rate measured concurrently by plasma disappearance [19]. While renal scintigraphy was performed on all those 41 hydronephrotic patients diagnosed through ultrasonography, 19 patients were diagnosed with non-obstructive bilateral pelvic dilation while the remaining 22 with mild to severe obstruction. These results classify hydronephrotic patients on a functional basis providing precise information for effective management of renal disorders.

Renal scintigraphy results showed that hydronephrotic kidneys had an almost

regular or minor reduction in relative function. It is very essential to define the grade of the hindrance. In this regard, ultrasound examination is not a preferred imaging technique to determine whether obstruction is responsible for hydronephrotic kidney or not [20]. In literature, several definitions have been reported of significant hydronephrosis and all such definition have common parameters including renal parenchyma, calyces, and pelvis. Consequently, renal ultrasonography, in conjunction with laboratory and clinical data, is more effective for the diagnosis of hydronephrosis. Moreover, we need renal scintigraphy for the functional characterization of hydronephrosis to determine intervention guidelines [21] [22] [23].

There were 4 patients reported with renal obstruction in ultrasonography. When renal scintigraphy was performed, two patients were diagnosed with renal obstruction based on a renal function which clearly states that ultrasound is insensitive to discerning between functional and anatomical impairment of renal disease [24]. In total, 19 out of 96 renal disease patients were diagnosed with the renal obstruction which reinforces precise functional characterization analysis revealed by renal scintigraphy. Abnormal renal US observed in the current study finding renal obstruction may be due to factors like interference by intestinal gas, ischemia, the expertise of the radiologist, and non-cooperation of the patients [25] [26]. Moreover, one patient was reported non-obstructive renal disease in ultrasonography but was confirmed with renal obstruction in renal scintigraphy. Such false-negative results in ultrasonography may have happened due to obesity or partial venous obstruction [27]. The presence of more than one radiologist and the lengthy duration of this study was not without consequence; nevertheless, these conditions well trigger real-life and non-experimental conditions. We suggest future prospective studies involving prolonged follow-up, age-specific results, and comparative assessment of these two tests to deduce comprehensive findings and reduce limitations. Additionally, all-inclusive results will help identify the optimum imaging protocol for renal disease and will address whether non-concordance exists.

A substantial amount of postvoid residual volume can have many outcome symptoms like overflow incontinence, urinary frequency, recurrent urinary tract infections, and nocturia. In some cases, measurement of postvoid residual volume is necessary to determine if there is any probability of renal disease. For this purpose, there is a need for an accurate and rapid as well as non-invasive procedure as demanded by the increasing scope of pharmacological treatment choices for urinary problems. Residual urine can be measured by catheterization of the urethra but carries the risk of trauma and infection [28] [29] [30]. Ultrasonography has been a method of choice for evaluating the pre-void/post-void bladder volume for the last three decades. The urinary bladder is hollow viscous, non-rigid, and fenced by the pelvic arrangements that might restrict its growth potential in specified ways. It is supposed that an upsurge in size would cause a rise in at least one of the three directions. Pre-void/post-void residual urine vo-

lume was determined in 15 patients with the renal disease through ultrasonography and three patients reflected abnormality in their postvoid residual urine volume which was more than 80 ml. Renal scintigraphy results reported renal obstruction, bilaterally dilated non-obstructed pelvis, and normal flow and function at both kidneys in all three patients respectively. One of the patients with normal flow and function at both kidneys but abnormal postvoid residual volume was diagnosed with an enlarged prostate gland.

In the current study, 64/68 patients were diagnosed with renal disease which is 94.1%. As a result, the sensitivity of renal US in diagnosing renal disease was 94% while renal scintigraphy was 85% because 82/96 patients were diagnosed with renal disease. Therefore, it is recommended to use both of these imaging techniques to validate renal disease diagnosis from a functional and anatomical perspective to augment the validation of results produced through either of the imaging techniques.

5. Conclusion

It is better if kidney disorder patients go through a standard scintigram after renal ultrasonography and serum creatinine. If scintigram is destructive for any kidney disease then no additional examination is essential. However, if scintigram is positive for kidney disease, a follow-up examination will be mandatory on a routine basis. A combination of functional and morphological imaging allows the classification of patients into persons demanding aggressive intervention and persons falling into the conservative management category. Early intervention can be made possible through the precise diagnosis of renal disease by correlating renal scintigraphy and renal ultrasonography results.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

Authors' Contribution Statement

MHA, AAA contributed to the conceptualization, formal analysis, investigation, YHA and AKB contributed to the methodology, writing, and Saeed M. Bafaraj contributed to the final editing. All authors have read and approved the final manuscript.

Ethics Statement

This retrospective survey was accepted by the Medical Ethical Review Committee of the King Abdulaziz University Hospital with reference number 646-19.

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