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Renal Function Assessment in Domestic Shorthair Cats Using Scintigraphy

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Abstract Scintigraphy, also known as a gamma scan, is a diagnostic imaging procedure utilized in the field of nuclear medicine. This procedure involves the use of radioisotopes attached to drugs, which serve as tracers. These tracers facilitate the creation of images that reveal the anatomical composition of the patient's internal organs and tissues. Scintigraphy provides distinctive insights into renal function, thereby complementing anatomical details obtained from magnetic resonance imaging and computed tomography scans. Its clinical applications include the assessment of anomalies, infections, and the evaluation of kidney function. The objective of this study was to evaluate the effectiveness of scintigraphy technique in assessing kidney function in cats. To obtain scintigraphy information, six adult healthy male cats were selected. The cats were anesthetized, and a dose of 4 millicuries of the radiopharmaceutical 99mTc-DTPA was injected into the saphenous vein of the animal simultaneously with the start of the scan. The emitted radiation was recorded by the camera for 30 minutes. The results obtained revealed that the total glomerular filtration rate was 125.66 ± 5.03 mL/min, with exclusive glomerular filtration rates for the left and right kidneys being 51.27 ± 2.29 and 48.78 ± 2.75 mL/min, respectively. The peak activity times were recorded as 4.4 ± 0.43 and 4.6 ± 0.12 minutes for the left and right kidneys, respectively. The results obtained from this study are within the normal range, which show the reliability of scintigraphy as a non-invasive, rapid, and accurate tool for evaluating renal indices in veterinary medicine.

Introduction

Chronic kidney disease (CKD) has been identified as a prevalent condition in felines, particularly in aged animals [1]. Specific systemic diseases associated with the kidneys in cats include lymphoma and infectious peritonitis [2]. The prevalence of kidney stones and nephritis in cats is common and has increased significantly over the past two decades [3]. Various techniques such as radiography, ultrasonography, Magnetic Resonance Imaging (MRI), and scintigraphy are used to evaluate renal morphology; radiography is the first and most accessible method [2]. Although Computed Tomography (CT) scans were once considered the primary method for examining infections and kidney enlargements, they are associated with challenges like high radiation exposure and difficulty controlling respiratory movements in animals [4]. MRI is a valuable diagnostic tool, but it is not without its limitations. These limitations include the potential for artifacts to be created from respiratory and other movements [4]. In 2007, Frieske et al. conducted a study on the transit time of the radiopharmaceutical 99mTc-EC in diabetic and healthy individuals. The results of this study indicated that the transit time through the kidneys was significantly prolonged in diabetic patients, thereby underscoring the efficacy of scintigraphy as a method for early detection of renal lesions, particularly in diabetic patients [5].

In scintigraphy, radioactive materials are utilized, which release radioactive atoms in different parts of the body, resulting in the emission of gamma rays from the radiopharmaceutical outside the organ where it is located [6]. Unlike radiography, ultrasonography, and endoscopy, scintigraphy possesses the capability for physiological evaluation. The primary purpose of this procedure is to facilitate the diagnosis of various medical conditions and to determine appropriate treatment modalities. This capacity extends to the calculation and display of various substances' distribution within a living organism [6]. The acquisition of physiological data concerning renal function necessitates the utilization of dynamic imaging modalities, although static imaging may be employed in select circumstances. The measurement of renal blood flow can be accomplished through the implementation of dynamic imaging with a gamma camera. The glomerular filtration rate (GFR) is generally determined using the radiopharmaceutical 99mTc-DTPA [7]. The most prevalent radiopharmaceutical in scintigraphy is 99mTc, selected due to its reduced radiation exposure to patients and its capacity to label a broad spectrum of chemical compounds [8]. Furthermore, the selection of 99mTc for renal function assessment is predicated on its almost complete filtration by renal glomeruli [8]. Scintigraphy's capacity to demonstrate the distribution and quantify the spread of substances in a living organism is well-documented. This methodology has been shown to differentiate between normal (physiological) and abnormal (pathological) tissue conditions, thereby establishing itself as a non-invasive, sensitive, and specific method for confirming and accurately diagnosing diseases [6].

This imaging modality facilitates the assessment of renal blood flow and the distinction between renal parenchyma and the urinary collecting system [7]. Scintigraphy is employed in the examination of diverse body organs, including the kidneys, bones, joints, lungs, lymph nodes, and thyroid. In the context of renal imaging, this method is particularly advantageous for diagnosing conditions such as renal aplasia and hypoplasia, kidney trauma, hydronephrosis, space-occupying tumors, obstruction, and stenosis [9]. The present study was conducted with the objective of collecting renal indices in domestic shorthair (DSH) cats by means of scintigraphy imaging for the use of local clinicians.

Materials and methods

Samples

Six adult male domestic shorthair cats (DSH) weighing approximately 3.5 ± 1.2 kilograms were selected for this study. After undergoing clinical examinations and laboratory tests, such as blood urea nitrogen (BUN) and creatinine, which confirmed their renal health, the animals were fasted for 12 hours prior to the procedure and had free access to water for each scan.

Preparation of 99mTc-DTPA

The preparation of the radioactive material entails the placement of a vacuum vial within a designated compartment of the generator. Subsequent to this step, the radioactive molybdenum within the generator undergoes radioactive decay, resulting in the conversion of the molybdenum into technetium. The technetium that is produced in this process is subsequently collected in the vacuum vial. The dose of 99mTc-DTPA for an adult human is 15 to 17 millicuries, prepared according to the aforementioned procedure. A dose of 4 millicuries was selected for the cats. To obtain 4 millicuries, a quantity of 10 millicuries was meticulously prepared, and the precise amount of radiopharmaceutical was measured by drawing 2 cc from the solution in the vial under a radioactive hood and in a protective compartment, yielding approximately 10 millicuries of radiopharmaceutical.

Scan procedure

The felines were anesthetized using a combination of ketamine (10% at a dose of 30 mg/kg) and diazepam (2% at a dose of 10 mg/kg) to ensure optimal sedation. For the scan with the radiopharmaceutical 99mTc-DTPA, the animal was positioned supine on a specialized table to facilitate the scintigraphy procedure. The syringe containing the radiopharmaceutical was positioned in close proximity to the bladder and kidneys, and the emitted radiation was recorded by the camera and displayed on a monitor screen. The midpoint between the two kidneys was centered on the monitor and camera. Due to the diminutive size of the patient, the camera was set in zoom mode with zero rotation, and the device was operated for a duration of 30 minutes. The radiopharmaceutical was injected rapidly into the saphenous vein of the animal, synchronized with the initiation of the scan, allowing for observation of its movement from the abdominal aorta to the kidneys and subsequently to the bladder. This process was recorded sequentially on the monitor screen, facilitating the observation of the movement. A computer program was utilized to calculate the values of parameters associated with specific and general GFR, peak activity, and the contribution of each kidney to excretion. These parameters were prepared separately for each cat. Subsequent to imaging, the syringes containing the radiopharmaceutical were placed in lead-lined protective containers. The animal's condition and the execution of the scan were monitored from behind a lead-lined protective wall.

Statistical analysis

For statistical analysis, the SPSS software version 26 was used, and a p-value less than 0.05 was considered to be significant.

Results

The parameters of interest, including background percentage, elimination half-life, activity in the first three minutes, peak activity time, and both specific and general GFR for each kidney, were measured using the radiopharmaceuticals 99mTc-DTPA and 99mTc-EC in a group of six DSH cats. The resulting data are presented in Table 1 and illustrated in Figures 1 and 2.

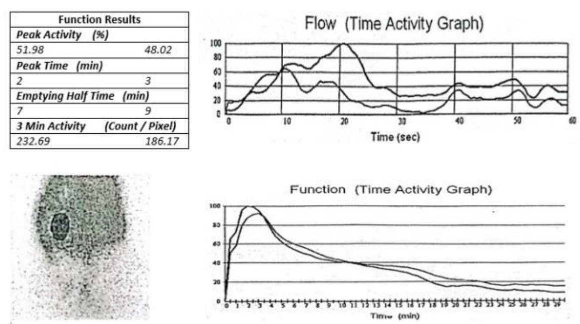

Fig 1. A kidney dynamic scan by 99mTc radiopharmaceutical: flow and function parameters.

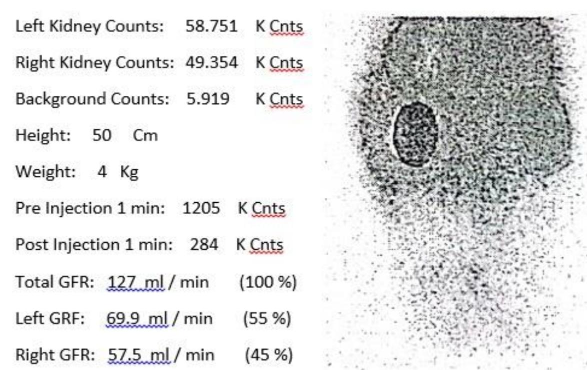

Fig 2. A kidney dynamic scan by 99mTc radiopharmaceutical: total and exclusive GFR values, as well as percentages of each kidney, expressed in the form of a gate.

The results obtained from this study indicate that the functional division in both left and right kidney groups was in the range of 45-55%, suggesting that both kidneys are functioning adequately.

Table 1: Data obtained from scintigraphy imaging on a group of six DSH cats

Parameters	Emptying half time (min)	Time of peak activity (min)	Peak activity (%)	Individual GFR (ml / min)	Total GFR (ml / min)
Left kidney	7.7 ± 0.39 *	3.1 ± 0.33	51.27 ± 2.29	64.42 ± 4.27	125.3 ± 5.03
Right kidney	8.3 ± 0.52	3.43 ± 0.12	48.87 ± 2.75	62.24 ± 4.32	

* Data was presented as Mean ± SEM

Discussion

In contemporary medical practice, a plethora of nuclear medicine techniques have been adopted by hospitals, with a significant focus on cancer detection. These methodologies are also utilized in the study of diseases affecting the heart, blood, lungs, bones, and kidneys [10]. Scintigraphy, a form of imaging, facilitates physiological evaluation of various body organs, including the kidneys. This technique is non-invasive and exhibits a high degree of accuracy, particularly in quantifying the rate of tubular and glomerular filtration in the kidneys [5, 11]. Scintigraphy is a suitable method for evaluating different body tissues due to its precision and non-invasive nature [6]. The kidney plays a crucial role in maintaining osmotic pressure and body balance [12]. In 2008, scintigraphy was used to investigate potential hydronephrosis and obstruction at the junction of the ureter and renal pelvis, demonstrating its accuracy in evaluating renal disorders [13]. In a 2007 study by Frieske et al., it was found that scintigraphy can detect early renal lesions caused by diabetes, underscoring its importance in the diagnosis of renal disorders [5]. Kibar et al. in 2003 discovered that renal parenchymal lesions can be identified using static scans [14]. Additionally, Berger et al. in 2017 emphasized that scintigraphy can assess renal blood flow and urology [15]. Renal scintigraphy has been identified as a valuable tool for the early detection of kidney dysfunction, as evidenced by a case study demonstrating its superiority to routine tests in detecting loss of kidney function [16]. The values obtained for peak activity time and elimination half-life in various studies are consistent with our findings [17]. The variation in GFR values is attributable to differences in measurement methods and physiological adjustments by the kidneys [18, 4]. The present study was conducted to evaluate the effectiveness of renal scintigraphy in assessing kidney function in domestic shorthair cats in Kerman. The results demonstrated that the measured physiological indices were within the normal range, thereby confirming the reliability of scintigraphy not only in humans but also in animal species.

The present study corroborates earlier research, demonstrating that scintigraphy can accurately evaluate dynamic changes in kidney function and can be used to monitor renal performance under various conditions, including the effects of drugs and environmental factors. This underscores the mounting importance of employing this method in future research, particularly in studying the effects of renal drugs and environmental factors. The findings of this study are valuable not only for the scientific and research community in veterinary medicine but also for practicing clinicians. The renal scintigraphy indices obtained from domestic shorthair cats in Kerman can serve as a reliable reference for clinical evaluation and diagnosis in this geographic region. Accurate documentation of these indices contributes to improved understanding of renal function in animals and paves the way for future studies on the impacts of therapeutic and environmental factors on kidney health.

Conclusion

This study evaluated the effectiveness of scintigraphy for assessing renal function in DSH cats in Kerman, demonstrating its reliability in measuring glomerular filtration rate and other renal parameters. While scintigraphy is a valuable tool for early detection of renal diseases, its use should be contextualized within the advancements in veterinary imaging, especially with the growing accessibility of MRI and CT scans. Due to the limited availability of scintigraphy equipment in veterinary practices, future research should conduct comparative studies to assess its diagnostic accuracy against these newer imaging modalities. Additionally, expanding the research to different cat breeds and examining the influence of environmental and pharmaceutical factors on renal function would improve the applicability of the results. The findings can guide local veterinarians in diagnosing and treating feline renal diseases, but should be evaluated in light of evolving imaging technologies.

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Conflict of interest

The authors declare that they have no competing interests.

Ethical approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

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