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Original research

The Utility of Radioisotope Renography in Assessment of Renal Function: A Single - Center Experience

Amin Elzaki

Department of Radiological Sciences, College of Applied Medical Sciences, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia

*Corresponding author: Amin Elzaki; *Orcid Id: 0000-0001-5277-1032*; *a.zaki@tu.edu.sa*

Abstract

Background: A growing body of evidence has demonstrated the utility and reliability of 99mTc-mercaptoacetyltriglycine (99mTc-MAG3) diuretic renography in a wide range of renal disorders.
Methods: In this retrospective study, we retrieved the medical records of patients who were referred to the Radiology Department of King Abdulaziz Specialist Hospital, Taif, Saudi Arabia due to suspected renal disease and were scheduled to undergo 99mTc-MAG3 diuretic renography during the period from January 2020 to November 2021.
Results: The medical records of 280 patients were retrieved. Most of the patients had either suspected obstructive (n = 80; 28.6%) or non-obstructive hydronephrosis (n = 60; 21.4%). The left kidney was affected in more than half of the patients (n = 155; 55.4%). In terms of split kidney functions, the right kidney had a median function of 50.9 (38.5–75.5); overall, 39 (69.6%) had good right kidney function. The left kidney had a median function of 49.4 (24.5–61.5); overall, 33 (58.9%) had good left kidney function.
Conclusion: Radioisotope renography is a useful tool for assessing renal functions in real-life settings. The technique provides a safe and easy-to-use tool that can guide the management approaches of patients presenting with renal diseases. It can reduce the interval from presentation to definitive diagnosis and ensure the prompt initiation of therapy after diagnosis. The present study's results indicated that radioisotope renography was useful in providing reference values and visual interpretation of impaired renal function, obstructive uropathy, renal stenosis, and acute tubular necrosis. Nonetheless, as the current literature reveals a significant impact of operator experience on the reliability of radioisotope renography, regular reader training is encouraged.

Keywords: ***Radioisotope Renography; Renal Function; Utility; Nuclear Medicine***

1. Introduction

Renal functions play a crucial role in maintaining the normal physiological function of the body and its hemostasis through excretory and hormonal properties. Thus, a proper assessment of renal function represents a cornerstone during routine evaluation of several renal disorders through biochemical tests and radiological assessments [1]. Historically, radiological evaluation has played a limited role in the evaluation of renal functions compared with biochemical measurements, and its use was mainly for assessing anatomic changes in kidney size and density, as well as parenchymal alterations [2]. However, the past few decades have witnessed dramatic improvements in our understanding of renal functions and radiological techniques, which have led to the emergence of novel imaging modalities to evaluate functional changes within the kidney [3]. Advanced modalities, such as contrast-enhanced ultrasound (CEUS), computed tomography (CT), magnetic resonance imaging (MRI), and positron emission tomography (PET), have been widely studied to assess their utility in detecting renal perfusion, oxygen delivery, and glomerular filtration [4-7]. Besides, imaging assessment of the adequacy of renal excretion of electrolytes and metabolites has become possible with the introduction of sodium and hyperpolarized MRI [1]. Moreover, MRI sequences, CEUS, and CXCR4-targeted PET have gained popularity as reliable alternatives to renal biopsy for the detection of renal inflammation and fibrosis [8-10].

Nonetheless, despite the potential of these novel modalities in evaluating renal functions, they face several challenges in their clinical applications due to high cost, limited availability in many centers, complexity, and risks of radiation exposure posed by some of these modalities [1]. Diuretic renography is a simple, non-invasive test for the dynamic assessment of renal obstruction and functions initially described in the late 1950s. This modality is based on real-time scanning of an intravenously administrated radiopharmaceutical agent via dynamic renal scintigraphy (DRS) to draw activity curves for renal functions [11]. Diuretic renography provides both qualitative and quantitative measures of renal functions, such as the relative function of each kidney and the time of the peak of the renographic curve (Tmax) [12]. While several radiopharmaceutical agents, such as 99mTc-mercaptoacetyltriglycine (99mTc-MAG3) and 123I-OIH, are available for diuretic renography, 99mTc-MAG3 is the most widely utilized agent in the assessment of renal functions due to its higher excretion rate than other agents [13].

A growing body of evidence has demonstrated the utility and reliability of 99mTc-MAG3 diuretic renography in a wide range of renal disorders, such as identifying renal obstruction, uropathy, hydronephrosis, and after chemotherapy [11,14]. The vast majority

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of the agent (95%) is excreted by the proximal renal tubules, which permits real-time evaluation of the excretory functions of the kidney, as well as the assessment of any obstruction in the renal flow through the pyelocalyceal system and bladder [12]. The 99mTc-MAG3 agent has proven its safety for both children and adults [13]. In addition, 99mTc-MAG3 has shown higher binding affinity to protein, leading to slow plasma clearance, which in turn results in high-quality imaging regardless of renal function impairment [11]. It is usually preferred over the other agent (Tc-99m DTPA) because it has plasma clearance higher by 40% and a shorter half-life, which makes it more practical to evaluate renal function. Recent consensuses have been published over the past two decades by international societies to standardize radioisotope renography procedures [15]. There are several indications for 99mTc-MAG3 diuretic renography, including suspected obstructive uropathy in both symptomatic and asymptomatic patients, as well as for assessing the degree of renal function in patients with nephropathy. However, 99mTc-MAG3 diuretic renography should be performed only when there is sufficiently reliable serial imaging.

In a 2013 report by Yousef et al., nearly 28% and 16% of patients who underwent radioisotope renography at Khartoum University Hospital had abnormal right and left kidney function, respectively [16]. To date, real-world practice regarding the utilization of radioisotope renography is still lacking. Thus, we aimed to provide a single-center experience regarding the utility of radioisotope renography in the assessment of renal functions among patients presenting with renal diseases. Besides, we described the reference values obtained from the radioisotope renography and their interpretation.

2. Materials and Methods

The present study was initiated after obtaining protocol approval from the responsible ethics committees in the Directorate of Health Affairs, Taif, Saudi Arabia. Owing to the retrospective nature of the study, the need for written informed consent was waived. We confirm that the present study did not violate any of the ethics principles declared in the latest version of the Declaration of Helsinki [17]. The preparation of the present manuscript complies with the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [18].

2.1. Study Design and Population

In this retrospective study, we retrieved the medical records of patients who were referred to the Radiology Department of King Abdulaziz Specialist Hospital, Taif, Saudi Arabia due to suspected renal disease and were scheduled to undergo 99mTc-MAG3 diuretic renography during the period from January 2020 to November 2021. There were no restrictions regarding the age of the patients or their nationality. We included only records with complete documentation of the split-function results and anatomic findings of both kidneys. Patients were excluded in cases of poor quality of the obtained curves of the diuretic renography, documented interruption of imaging acquisition, and/or short imaging protocol.

2.2. Data Collection and Diuretic Renography Protocol

The following data were retrieved from the files of the eligible patients: demographic characteristics, suspected and final diagnoses, side of kidney affection, and the quantitative results of the diuretic renography, including split function in %, glomerular filtration rate (GFR), MAG3 clearance rate, and Tmax.

All diuretic renography procedures were performed in concordance with the standardized protocol of our center using GE Healthcare scintillation cameras equipped with low-energy general-purpose collimators (LEGP). The patients were instructed to drink water and urinate 30 minutes before imaging acquisition. Then, the patients were positioned supine and injected with an intravenous bolus dose (75 MBq) of 99mTc-MAG3, followed by the injection of furosemide 20 mg 10 min later. The imaging acquisition lasted for 10–20 min using 128 × 128 matrices in posterior view and was followed by post-micturition images in an upright position. The images were analyzed using Hermes Gold (Hermes Medical Solutions, Stockholm, Sweden) software (**Figure 1**).

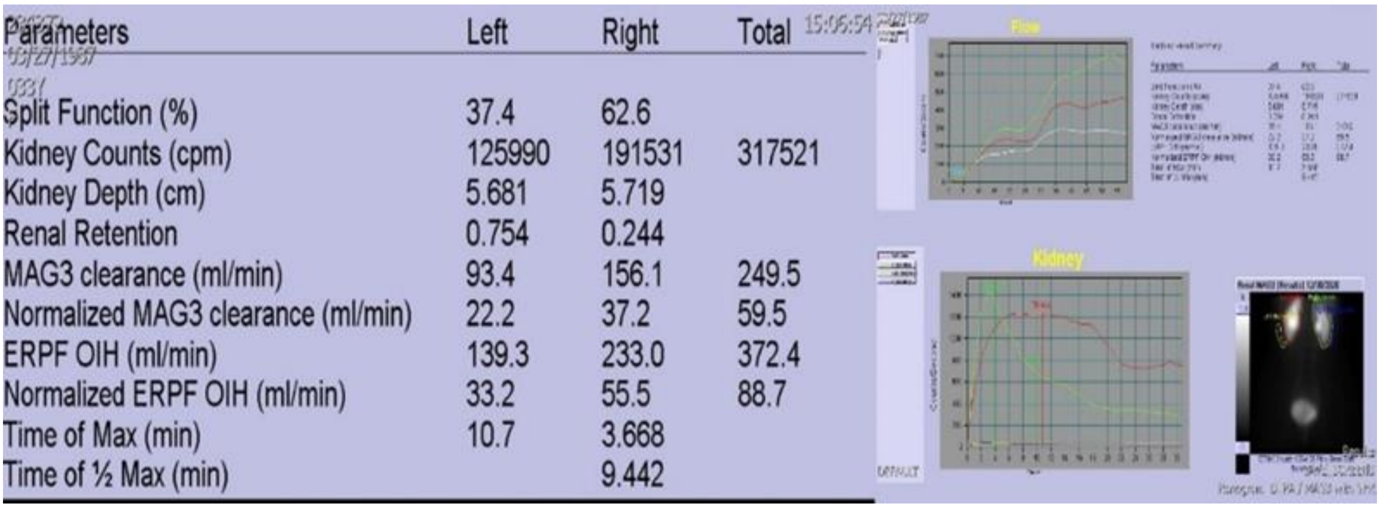

Figure 1: Example of the quantitative and visual findings of 99mTc-MAG3 radioisotope renography

2.3. Statistical Analysis

Quantitative and qualitative data were described as the median with interquartile range (IQR) and frequencies with percentages, respectively. Data were checked for any relevant comparisons between the obtained parameters, with an alpha level below 0.05 for statistical significance. All analysis was done by SPSS version 25 for Windows.

3. Results

The medical records of 280 patients were retrieved (**Figures 2 and 3**). The median age of the included patients was 33 (23–48) years old, and 145 (51.8%) patients were female. The majority of the patients had either suspected obstructive (n = 80; 28.6%) or non-obstructive hydronephrosis (n = 60; 21.4%). The left kidney was affected in more than half of the patients (n = 155; 55.4%). Nearly 21% of the patients (n = 60) underwent diuretic renography for follow-up (**Table 1**).

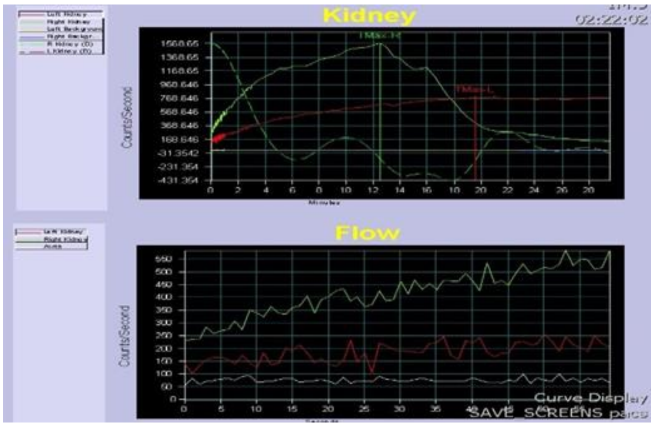

Figure 2: 99mTc-MAG3 renal dynamic scan showing good functioning right kidney, enlarged diminished functioning left kidneys associated with significance non-obstructive hydronephrosis.

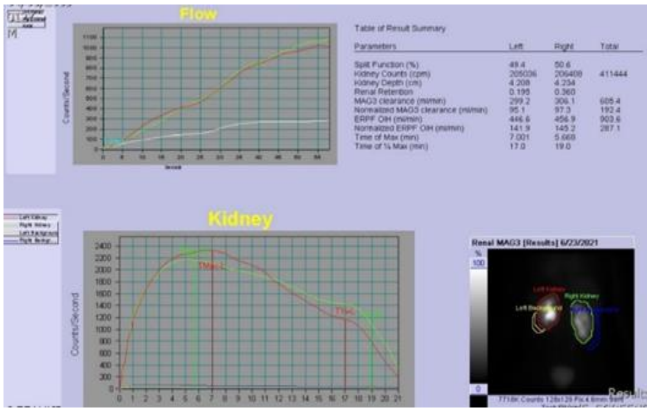

Figure 3: 99mTc-MAG3 renal dynamic scan showing good functioning right kidney with significantly non-obstruction hydronephrosis, good functioning left kidneys with minor pelvic dilatation

Table 1: Characteristics of the included patients (n =280)

Variables	Patients (n =280)
Age, median (IQR)	33 (23 – 48)
Female, No. (%)	145 (51.8%)
Suspected diagnosis, No. (%)	
- Obstructive hydronephrosis	80 (28.6%)
- Non-obstructive hydronephrosis	60 (21.4%)
- Atrophic kidney	25 (8.9%)
- Bilateral renal impairment	10 (3.6%)
- CRF	10 (3.6%)
- Hypoplastic kidney	10 (3.6%)
- Moderate renal failure	10 (3.6%)
- Obstructive PUJ	15 (5.4%)
- Pelvic dilatation	10 (3.6%)
- Pyeloplasty	15 (5.4%)
- Renal Transplant	5 (1.8%)
- Stones	10 (3.6%)
Side, No. (%)	
- Left	155 (55.4%)
- Right	95 (33.9%)
- Bilateral	10 (3.6%)

In terms of split kidney functions, the right kidney had a median function of 50.9 (38.5–75.5); overall, 39 (69.6%) had good right kidney function. On the other hand, the left kidney had a median function of 49.4 (24.5–61.5); overall, 33 (58.9%) had good left kidney function (**Figure 4**).

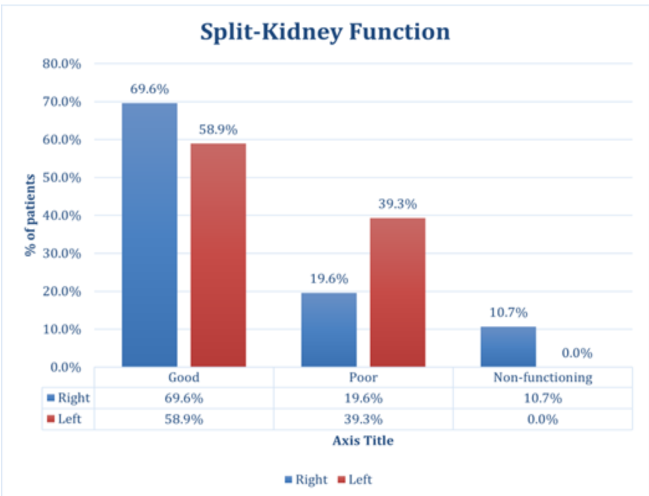

Figure 4: Findings of split-kidney functions

The medical records largely lacked the findings of other parameters, such as GFR and Tmax. The median GFR in the 80 patients with available data was 81.7 (63.3–104).

4. Discussion

Since its first description in the late 1950s, radioisotope renography has gained popularity as a valid and reliable approach for the semi-quantitative evaluation of differential renal function and the detection of renal hydronephrosis [19]. The concept of radioisotope renography depends on its ability to reflect the functional and drainage capacity of the kidney, thereby differentiating between obstructive and non-obstructive uropathy. While the utilization of radioisotope renography suffered from the lack of standardized procedures and interpretation, which limited its reproducibility, recent consensuses have been published over the past two decades by international societies to standardize radioisotope renography procedures [20]. However, real-world practice regarding the utilization of radioisotope renography is still lacking. Thus, we aimed to provide a single-center experience regarding the utility of radioisotope renography in the assessment of renal functions among patients presenting with renal diseases. Besides, we described the reference values obtained from the radioisotope renography and their interpretation.

Basically, radioisotope renography monitors the renal uptake and washout of the radiopharmaceutical under the effect of an intravenous diuretic to assess kidney function. Differential renal function is one of the six key parameters of radioisotope renography, which demonstrates the relative functional capacity of each kidney [21]. Previous reports demonstrated the existence of nearly 5% unilateral variations in the results of differential renal function, which was found to be an insignificant difference. Nonetheless, a unilateral variation of 7–9% may reflect a considerable impairment in renal function [22]. Patients with >10% unilateral variation was found to be associated with an increased risk of renal decline [21].

Nonetheless, it should be noted that the hydronephrotic kidney may present with a relatively higher function than the normal contralateral one, known as supernormal function phenomena; several theories have been proposed to explain such phenomena, including true compensatory hyperfunction or a technical artifact [23,24]. In the present study, we found that differential renal function was universally reported in all medical records of the included patients. The right kidney had a median function of 50.9 (38.5–75.5); overall, 39 (69.6%) had good right kidney function. On the other hand, the left kidney had a median function of 49.4 (24.5–61.5); overall, 33 (58.9%) had good left kidney function. In a 2013 report by Yousef et al., nearly 28% and 16% of patients who underwent radioisotope renography at Khartoum University Hospital had abnormal right and left kidney function, respectively [16]. Notably, in a recent report by Cichocki et al., it was found that the accuracy of differential renal function is affected by its parameters; their results indicated that the uptake constant had more diagnostic value than the mean transit time and parenchymal transit time [25]. Thus, future reports should investigate the contribution of mean transit time and parenchymal transit time to the potential errors of differential renal function findings.

Measurement of the GFR is a commonly employed index for the assessment of renal function. The 99mTc-MAG3 diuretic renography can reliably assess the GFR, with the advantages of being a fast modality that requires only one blood sample and has comparable accuracy to 24-hour creatinine clearance [26,27]. Another important parameter during the 99mTc-MAG3 diuretic renography procedure is the time to peak (Tmax), which can be impaired in the setting of renal artery stenosis [28]. Despite the obvious benefits of such measures, we found that the GFR and Tmax were rarely reported within the medical records of the patients. Thus, educational efforts should be directed toward the importance of documenting the key parameters of radioisotope renography and their interpretations.

In the present study, the dose of 99mTc-MAG3 was 75MBq in our institution. This runs in parallel with Taylor et al., who elaborated that the acceptable and safe dose for 99mTc-MAG3 was 37–185 MBq [29]. Other reports and expert opinions supported these findings [30,31]. According to Sachpekidis et al., this dose range is sufficient to ensure the reliability of 99mTc-MAG3 diuretic renography [32].

While the current study is one of a few reports that assessed the utility of radioisotope renography in the assessment of renal function in routine clinical practice, it should be noted that it suffers from some limitations. First, the study was retrospective, with the inherited limitations of misclassification and selection bias. Besides, the medical records of the included patients were largely confined to the results of differential renal function, with limited reporting of other parameters of radioisotope renography. Thus, a comprehensive evaluation of the radioisotope renography findings and their correlation with the diagnosis of the affected patients was not possible.

5. Conclusion

Radioisotope renography is a useful tool for assessing renal functions in real-life settings. The technique provides a safe and easy-to-use tool that can guide the management approaches of patients presenting with renal diseases. It can reduce the interval from presentation to definitive diagnosis and ensure the prompt initiation of therapy after diagnosis. The present study's results indicated that radioisotope renography was useful in providing reference values and visual interpretation of impaired renal function, obstructive uropathy, renal stenosis, and acute tubular necrosis. Nonetheless, as the current literature reveals a significant impact of operator experience on the reliability of radioisotope renography, it is encouraged to conduct reader training regularly. Besides, measures should be taken to increase the number of accredited operators in secondary and tertiary health centers.

Declarations

Funding

This research received no external funding.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Directorate of Health Affairs, Taif Health Committee no KACST, KSA: HAP-02-T-067

Informed Consent Statement

Owing to the retrospective nature of the study, the need for written informed consent was waived.

Data Availability Statement

The data of the research is available upon request from the corresponding author.

Conflicts of Interest

The authors declare no conflict of interest.

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References

1. Thurman J, Gueler F. Recent advances in renal imaging. F1000Research 2018;7. https://doi.org/10.12688/F1000RESEARCH.16188.1.
2. Bokacheva L, Rusinek H, Zhang JL, Lee VS. Assessment of Renal Function with Dynamic Contrast Enhanced MR Imaging. Magnetic Resonance Imaging Clinics of North America 2008;16:597. https://doi.org/10.1016/J.MRIC.2008.07.001.
3. Chandarana H, Lee VS. Renal Functional MRI: Are We Ready for Clinical Application? Http://DxDoiOrg/102214/AJR092390 2012;192:1550–7. https://doi.org/10.2214/AJR.09.2390.
4. Zhang JL, Morrell G, Rusinek H, Sigmund EE, Chandarana H, Lerman LO, et al. New magnetic resonance imaging methods in nephrology. Kidney International 2014;85:768–78. https://doi.org/10.1038/KI.2013.361.
5. Pruijm M, Mendichovszky IA, Liss P, van der Niepen P, Textor SC, Lerman LO, et al. Renal blood oxygenation

level-dependent magnetic resonance imaging to measure renal tissue oxygenation: a statement paper and systematic review. Nephrology, Dialysis, Transplantation : Official Publication of the European Dialysis and Transplant Association - European Renal Association 2018;33:ii22–8. https://doi.org/10.1093/NDT/GFY243.
6. Cosgrove D, Lassau N. Imaging of perfusion using ultrasound. European Journal of Nuclear Medicine and Molecular Imaging 2010;37 Suppl 1. https://doi.org/10.1007/S00259-010-1537-7.
7. Odudu A, Nery F, Harteveld AA, Evans RG, Pendse D, Buchanan CE, et al. Arterial spin labelling MRI to measure renal perfusion: a systematic review and statement paper. Nephrology, Dialysis, Transplantation : Official Publication of the European Dialysis and Transplant Association - European Renal Association 2018;33:ii15–21. https://doi.org/10.1093/NDT/GFY180.
8. Baues M, Dasgupta A, Ehling J, Prakash J, Boor P, Tacke F, et al. Fibrosis imaging: Current concepts and future directions. Advanced Drug Delivery Reviews 2017;121:9–26. https://doi.org/10.1016/J.ADDR.2017.10.013.
9. Goya C, Kilinc F, Hamidi C, Yavuz A, Yildirim Y, Cetincakmak MG, et al. Acoustic radiation force impulse imaging for evaluation of renal parenchyma elasticity in diabetic nephropathy. AJR American Journal of Roentgenology 2015;204:324–9. https://doi.org/10.2214/AJR.14.12493.
10. Derlin T, Gueler F, Bräsen JH, Schmitz J, Hartung D, Herrmann TR, et al. Integrating MRI and Chemokine Receptor CXCR4-Targeted PET for Detection of Leukocyte Infiltration in Complicated Urinary Tract Infections After Kidney Transplantation. Journal of Nuclear Medicine : Official Publication, Society of Nuclear Medicine 2017;58:1831–7. https://doi.org/10.2967/JNUMED.117.193037.
11. Cichocki P, Filipczak K, Adamczewski Z, Kuśmierek J, Płachcińska A. Assessment of Renal Function Based on Dynamic Scintigraphy Parameters in the Diagnosis of Obstructive Uro/Nephropathy. Journal of Clinical Medicine 2021;10:1–15. https://doi.org/10.3390/JCM10030529.
12. Taylor AT, Brandon DC, de Palma D, Blaufox MD, Durand E, Erbas B, et al. SNMMI Procedure Standard/EANM Practice Guideline for Diuretic Renal Scintigraphy in Adults With Suspected Upper Urinary Tract Obstruction 1.0. Seminars in Nuclear Medicine 2018;48:377–90. https://doi.org/10.1053/J.SEMNUCLMED.2018.02.010.
13. Prigent A, Cosgriff P, Gates GF, Granerus G, Fine EJ, Itoh K, et al. Consensus report on quality control of quantitative measurements of renal function obtained from the renogram: International Consensus Committee from the Scientific Committee of Radionuclides in Nephrourology. Seminars in Nuclear Medicine 1999;29:146–59. https://doi.org/10.1016/S0001-2998(99)80005-1.
14. Wang L, Chen K, Xu Q. The Application of 99mTc-DTPA Renal Dynamic Imaging to Measuring Renal Function of Children with Acute Lymphoblastic Leukemia after Induction Therapy. BioMed Research International 2020;2020. https://doi.org/10.1155/2020/3687134.
15. Eskild-Jensen A, Gordon I, Piepsz A, Frøkiær J. Interpretation of the renogram: problems and pitfalls in hydronephrosis in children. BJU International 2004;94:887–92. https://doi.org/10.1111/J.1464-410X.2004.05052.X.
16. Yousef M, Salih S, Sulieman A, Ali N, Ahmed A. Evaluation of renal functions using isotopic renogram and biochemical tests. Sudan Medical Monitor 2013;|. https://doi.org/10.4103/1858-5000.132612.
17. JAVA. Declaration of Helsinki World Medical Association Declaration of Helsinki. Bulletin of the World Health Organization 2013;79:373–4. https://doi.org/S0042-96862001000400016 [pii].
18. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. International Journal of Surgery 2014. https://doi.org/10.1016/j.ijsu.2014.07.013.
19. Bayne CE, Majd M, Rushton HG. Diuresis renography in the evaluation and management of pediatric hydronephrosis: What have we learned? Journal of Pediatric Urology 2019;15:128–37. https://doi.org/10.1016/J.JPUROL.2019.01.011.
20. Caglar M, Gedik GK, Karabulut E. Differential renal function estimation by dynamic renal scintigraphy: influence of background definition and radiopharmaceutical. Nuclear Medicine Communications 2008;29:1002–5. https://doi.org/10.1097/MNM.0B013E32830978AF.
21. Klingensmith WC, Lammertse DP, Briggs DE, Smith WI, Roberts JF, Froelich JW, et al. Technetium-99m-MAG3 renal studies in spinal cord injury patients: Normal range, reproducibility, and change as a function of duration and level of injury. Spinal Cord 1996;34:338–45. https://doi.org/10.1038/sc.1996.62.
22. Assmus MA, Kiddoo DA, Hung RW, Metcalfe PD. Initially Asymmetrical Function on MAG3 Renography Increases Incidence of Adverse Outcomes. The Journal of Urology 2016;195:1196–202. https://doi.org/10.1016/J.JURO.2015.11.011.
23. Oh SJ, Dae Hyuk Moon, Kang W, Young Seo Park, Park T, Kun Suk Kim. Supranormal differential renal function is real but may be pathological: assessment by 99m technetium mercaptoacetyltriglycine renal scan of congenital unilateral hydronephrosis. The Journal of Urology 2001;165:2300–4. https://doi.org/10.1097/00005392-200106001-00021.
24. Martín-Solé O, Soria-Gondek A, Pérez-Bertólez S, Paredes P, Tarrado X, García-Aparicio L. Value of supranormal function on 99mTc-mercaptoacetyltriglycine renal scan in paediatric patients with obstructive hydronephrosis. BJU International 2019;124:842–8. https://doi.org/10.1111/bju.14781.
25. Cichocki P, Filipczak K, Adamczewski Z, Kuśmierek J, Płachcińska A. Assessment of Renal Function Based on Dynamic Scintigraphy Parameters in the Diagnosis of Obstructive Uro/Nephropathy. Journal of Clinical Medicine 2021;10:1–15. https://doi.org/10.3390/JCM10030529.
26. Assadi M, Eftekhari M, Hozhabrosadati M, Saghari M, Ebrahimi A, Nabipour I, et al. Comparison of methods for determination of glomerular filtration rate: Low and high-dose Tc-99m-DTPA renography, predicted creatinine clearance method, and plasma sample method. International Urology and Nephrology 2008;40:1059–65. https://doi.org/10.1007/s11255-008-9446-4.
27. Andersen TB, Jødal L, Nielsen NS, Petersen LJ. Comparison of simultaneous plasma clearance of 99mTc-

DTPA and 51Cr-EDTA: can one tracer replace the other? Scandinavian Journal of Clinical and Laboratory Investigation 2019;79:463–7. https://doi.org/10.1080/00365513.2019.1658217.
28. Tartaglione G, Townsend DM, Bassi PF, Delgado Bolton RC, Giammarile F, Rubello D. Diuresis renography in equivocal urinary tract obstruction. A historical perspective. Biomedicine & Pharmacotherapy = Biomedecine & Pharmacotherapie 2019;116:108981. https://doi.org/10.1016/J.BIOPHA.2019.108981.
29. Taylor AT, Folks RD, Rahman AKMF, Polsani A, Dubovsky EV, Halkar R. et al. (99m)Tc-MAG(3): image wisely. Radiology. 2017;284:200-9.
30. Taylor A, Schuster DM, Alazraki N. A clinician's guide to nuclear medicine. 2nd ed. Reston, Va: Society of Nuclear Medicine, 2006; 50.
31. Ziessman HA, O'Malley JP, Thrall JH, Fahey FH. Genitourinary system. In: The requisites: nuclear medicine. 4th ed. Philadelphia, Pa: Elsevier Saunders, 2014; 175.
32. Sachpekidis, C.; Schepers, R.; Marti, M.; Kopp-Schneider, A.; Alberts, I.; Keramida, G.; Afshar-Oromieh, A.; Rominger, A. 99mTc-MAG3 Diuretic Renography: Intra- and Inter-Observer Repeatability in the Assessment of Renal Function. Diagnostics 2020, 10, 709. https://doi.org/10.3390/diagnostics10090709