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The role of nuclear medicine techniques; Tc-99m-labeled dimercaptosuccinic acid, diethylenetriaminepentaacetic acid, and mercaptoacetyltriglycine scintigraphies in pediatric surgery

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ABSTRACT

The purpose of this review is to highlight the pivotal role of nuclear medicine in pediatric surgery, specifically in the diagnosis and management of nephro-urological conditions. This review focuses on the applications and advantages of three key nuclear medicine techniques: Tc-99m dimercaptosuccinic acid (DMSA), Tc-99m diethylenetriaminepentaacetic acid (DTPA), and Tc-99m mercaptoacetyltriglycine (MAG3) scintigraphies. These imaging modalities are crucial for providing detailed anatomical and functional information with minimal invasiveness, essential for evaluating congenital anomalies, urinary tract infections, and obstructive uropathies in children. DMSA Scintigraphy is established as the gold standard for detecting renal cortical scarring and assessing functional renal parenchymal damage. It offers superior sensitivity and specificity compared to other imaging techniques, making it indispensable for identifying renal scars from recurrent urinary tract infections or pyelonephritis. DTPA Scintigraphy is critical for measuring glomerular filtration rate (GFR) and analyzing renogram curves, providing quantitative assessments of renal function. It effectively evaluates renal perfusion and identifies perfusion defects and renal ischemia, essential for managing conditions like renal artery stenosis and unilateral kidney disease. MAG3 Scintigraphy excels in dynamic renal scintigraphy, particularly in patients with impaired renal function. It provides high-quality images and superior diagnostic capability, making it invaluable for assessing ureteropelvic junction obstruction and other obstructive uropathies in pediatric patients. The review concludes by emphasizing the integration of these scintigraphy techniques with SPECT/CT, enhancing diagnostic accuracy and providing comprehensive anatomical and functional insights. Despite concerns regarding radiation exposure, measures such as dose optimization and advanced imaging techniques ensure safety and efficacy in pediatric applications.

Keywords: Kidney diseases, radionuclide imaging, technetium Tc-99m dimercaptosuccinic acid, technetium Tc-99m diethylenetriaminepentaacetic acid

INTRODUCTION

Nuclear medicine plays a crucial role in pediatric surgery, particularly in the diagnosis and management of nephro-urological conditions. These conditions often require precise and accurate diagnostic tools to ensure effective treatment and management. Common conditions in pediatrics include congenital anomalies, urinary tract infections, and obstructive uropathies, among others.[1] Techniques such as Tc-99m dimercaptosuccinic acid (DMSA), Tc-99m diethylenetriaminepentaacetic acid (DTPA), and Tc-99m mercaptoacetyltriglycine (MAG3) scintigraphies are widely used due to their ability to provide detailed anatomical and functional information with minimal invasiveness. These tools are essential for the thorough evaluation and management of pediatric kidney diseases.[2,3]

DIMERCAPTOSUCCINIC ACID (DMSA) SCINTIGRAPHY

Indications and Use

Dimercaptosuccinic acid (DMSA) scintigraphy is primarily used in pediatric nephro-urological conditions for the detection of renal cortical scarring and functional renal parenchymal damage. This imaging technique is considered

the gold standard for evaluating renal parenchymal defects and is widely employed due to its high sensitivity and specificity.

1. **Detection of renal cortical scarring:** DMSA scintigraphy is highly effective in identifying renal cortical scars, which are often a result of recurrent urinary tract infections (UTIs) or pyelonephritis. Recent clinical research on acute pyelonephritis in children has shown that a significant portion (50%-91%) of those with febrile tract infections exhibit abnormal findings on DMSA scintigraphy. Furthermore, it was discovered that the majority of these children do not have detectable vesicoureteral reflux. However, when vesicoureteral reflux is present, DMSA scintigraphy reveals renal cortical abnormalities in 79-86% of the affected kidneys.[4] These scars indicate chronic kidney damage and can significantly impact renal function. Studies have shown that DMSA scintigraphy is superior to ultrasound in detecting these defects, with ultrasound having a sensitivity of only 36% compared to 96% specificity.[5]
2. **Assessment of functional renal parenchymal damage:** DMSA scans provide detailed images of the renal cortex, allowing for the assessment of functional renal parenchymal damage. This is crucial for diagnosing conditions such as renal dysplasia and for evaluating the extent of kidney damage after acute infections. The imaging technique helps in identifying focal and global defects in renal parenchyma, aiding in the management and treatment planning for affected children. [2]
3. **Comparison with other imaging modalities:** While newer imaging technologies, such as shear wave elastography (SWE) and unenhanced MRI, are being explored for similar purposes, DMSA scintigraphy remains the preferred method due to its established accuracy and reliability. Studies comparing SWE and DMSA have found that elastography does not yet match the performance of DMSA in predicting renal scarring.[6] Unenhanced MRI has shown promise as a non-radiative alternative, with high sensitivity and specificity for detecting renal scars in older children.[7]

Advantages of DMSA Scintigraphy

Dimercaptosuccinic acid (DMSA) scintigraphy is considered the gold standard for certain renal evaluations in pediatric nephro-urological conditions due to several key advantages:

1. **High sensitivity and specificity**: DMSA scintigraphy has a high sensitivity and specificity for detecting renal parenchymal defects and cortical scarring. Studies have shown that DMSA scintigraphy is significantly more sensitive than ultrasound (US) for identifying renal scars. For example, DMSA scintigraphy detected renal parenchymal defects in 31% of renal units compared to only 14% detected by US, highlighting its superior diagnostic accuracy.[5]
2. **Detailed renal cortical imaging**: DMSA scans provide detailed images of the renal cortex, allowing for precise identification of focal and global renal parenchymal defects. This is essential for diagnosing conditions such as renal scarring from recurrent urinary tract infections (UTIs) and pyelonephritis, enabling targeted and effective treatment plans.[2]
3. **Non-invasive and safe**: DMSA scintigraphy is a non-invasive procedure that involves minimal radiation exposure, making it safe for use in children. It offers a reliable and repeatable method for monitoring renal function and scarring over time without the need for more invasive diagnostic procedures.[8,9]
4. **Early detection and monitoring**: DMSA scintigraphy is effective in the early detection of renal scarring, which is crucial for preventing long-term kidney damage. It can also be used to monitor the progression or resolution of renal scarring in follow-up studies, providing valuable information for ongoing patient management.[10]
5. **Correlation with vesicoureteral reflux (VUR)**: DMSA scintigraphy is particularly useful in patients with vesicoureteral reflux (VUR). It provides detailed information on renal damage, correlating with the severity of VUR and helping to guide clinical management.[11,12] Even in cases of low-grade VUR, which might not be expected to cause significant damage, DMSA can detect early renal parenchymal injuries.[13]

DIETHYLENETRIAMINE PENTAACETIC ACID (DTPA) SCINTIGRAPHY

Indications and Use

Diethylenetriamine pentaacetic acid (DTPA) scintigraphy is widely used in assessing renal function due to its ability to measure glomerular filtration rate (GFR) and analyze renogram curves.

1. **Assessment of glomerular filtration rate (GFR)**: DTPA scintigraphy involves the use of technetium-99m labeled DTPA (Tc-99m DTPA), which is filtered exclusively by the glomeruli without any tubular reabsorption or secretion.[14] This makes it an ideal tracer for measuring GFR. The GFR is a crucial indicator of renal function, and DTPA scintigraphy provides an accurate and non-invasive method for its assessment.[15–17]
2. **Renogram curve analysis**: The renogram curve obtained from DTPA scintigraphy provides essential information about renal perfusion, function, and drainage. The analysis of this curve helps in diagnosing and monitoring various renal conditions such as obstructive uropathy, renal artery stenosis, and differential renal function in cases of unilateral kidney disease.[18]

Advantages

DTPA scintigraphy has several advantages in evaluating renal perfusion and function:

1. **Effectiveness in evaluating renal perfusion**: DTPA scintigraphy provides detailed information on renal blood flow and perfusion, which is critical for assessing the functional status of the kidneys. It helps in identifying perfusion defects and evaluating the

extent of renal ischemia, which is particularly useful in patients with conditions such as renal artery stenosis and post-surgical evaluations.[19]

2. **Quantitative analysis of renal function**: DTPA scintigraphy allows for the quantitative measurement of GFR, providing precise and reliable data that can be used to monitor renal function over time. This quantitative capability is essential for assessing the impact of various interventions and treatments on renal function and for early detection of renal dysfunction.[15]
3. **Non-invasive and safe**: As a non-invasive procedure, DTPA scintigraphy involves minimal discomfort and risk to the patient. It is particularly advantageous for pediatric and geriatric populations, where invasive procedures may pose significant risks. The procedure involves a small amount of radiation, which is generally well-tolerated and considered safe for routine clinical use.[14,18,20]

MERCAPTOACETYLTRIGLYCİINE (MAG3) SCINTIGRAPHY

Indications and Use

Mercaptoacetyltriglycine (MAG3) scintigraphy is widely used in dynamic renal scintigraphy, especially in cases of impaired renal function. It provides detailed information on renal perfusion, function, and drainage.

1. **Dynamic renal scintigraphy**: MAG3 is used in dynamic renal scintigraphy to assess renal perfusion and function. It is particularly useful for evaluating patients with impaired renal function due to its ability to provide clear images even when renal function is reduced. MAG3 scintigraphy helps in diagnosing and managing various renal conditions, including obstructive uropathies, renovascular hypertension, and differential renal function in patients with unilateral kidney disease.[2,21,22]
2. **Evaluating pediatric ureteropelvic junction obstruction (UPJO)**: MAG3 scintigraphy is commonly used to evaluate ureteropelvic junction obstruction (UPJO) in children. It helps in assessing the severity of obstruction and the functional status of the kidneys, which is critical for determining the appropriate surgical intervention. Studies have shown that MAG3 scintigraphy provides reliable measurements of split renal function, making it a valuable tool in the preoperative evaluation of UPJO.[23–25]

Advantages

MAG3 scintigraphy offers several advantages in evaluating renal function, particularly in pediatric patients:

1. **Superior image quality**: MAG3 provides superior image quality compared to other radiotracers like DTPA, especially in patients with impaired renal function. This is due to its higher extraction efficiency, which results in clearer and more detailed images of renal perfusion and function. This makes MAG3 scintigraphy particularly useful in pediatric assessments, where accurate imaging is crucial for diagnosis and treatment planning.[26]
2. **Diagnostic capability**: MAG3 scintigraphy is highly effective in diagnosing and monitoring renal conditions. It provides comprehensive information about renal perfusion, drainage, and function, which is essential for managing conditions such as obstructive uropathies, congenital anomalies, and renovascular diseases. Its ability to accurately measure split renal function is particularly beneficial in evaluating pediatric patients with complex renal conditions.[2]
3. **Non-invasive and safe**: MAG3 scintigraphy is a non-invasive procedure that involves minimal risk to the patient. It is particularly advantageous for pediatric patients, as it does not require sedation and has a low radiation dose. This makes it a safe and effective method for repeated evaluations, allowing for continuous monitoring of renal function over time.[23]

Clinical Applications in Pediatric Surgery

- **Diagnosis of Renal Conditions**
- **Renal Scarring and Cortical Damage**

Dimercaptosuccinic acid (DMSA) scintigraphy is extensively used for identifying renal scars and cortical defects in pediatric patients. DMSA scans are particularly valuable in detecting renal cortical scarring, which often results from acute pyelonephritis (APN) and recurrent urinary tract infections (UTIs). This imaging technique provides high-resolution images of the renal cortex, making it the gold standard for identifying and assessing the extent of renal scarring and cortical damage.[27,28]

1. **Identifying renal scars**: DMSA scintigraphy is highly sensitive in detecting renal scars. Studies show that late DMSA scans (conducted six months post-infection) are effective in predicting vesicoureteral reflux (VUR) and long-lasting renal scars in children with first-time acute pyelonephritis. The presence of cortical defects on these scans indicates a higher risk of VUR and recurrent UTIs, making DMSA an essential tool for long-term renal health monitoring.[29]
2. **Evaluating cortical damage**: DMSA scans are critical for evaluating the extent of cortical damage following acute pyelonephritis. The scan's ability to detect permanent renal scarring aids in managing and predicting long-term outcomes for pediatric patients. Factors such as the presence and grade of VUR, as well as the age at diagnosis, significantly influence the likelihood of developing renal scars.[30]

- **Functional Renal Assessment**

Diethylenetriamine pentaacetic acid (DTPA) and mercaptoacetyltriglycine (MAG3) scintigraphy are crucial in evaluating renal function and detecting vesicoureteral reflux (VUR).

1. **DTPA scintigraphy**: DTPA scintigraphy is used to assess glomerular filtration rate (GFR) and renal function. This imaging technique is beneficial in

cases of impaired renal function, providing detailed information about renal perfusion and function. DTPA scans help in the early detection and monitoring of renal dysfunction, offering precise quantitative measurements of GFR, which are essential for managing chronic kidney disease and other renal conditions.[15]

2. **MAG3 scintigraphy**: MAG3 scintigraphy is preferred for its superior image quality and diagnostic capability, particularly in pediatric renal assessments. This technique is highly effective in evaluating renal perfusion and function, making it ideal for detecting VUR and other renal conditions. MAG3 scans provide detailed dynamic images, allowing for accurate measurement of renal function and detection of urinary tract obstructions and other anomalies. The high extraction efficiency of MAG3 ensures clearer and more reliable images, even in cases of impaired renal function.[22,26]

Management and Follow-Up

- **Congenital Anomalies and Urinary Infections**
- **Initial Diagnosis and Follow-Up**

1. **Dimercaptosuccinic acid (DMSA) scintigraphy**: DMSA scintigraphy is a critical tool for the initial diagnosis and follow-up of congenital renal anomalies and recurrent urinary infections. It is highly effective in identifying renal scars and cortical defects caused by urinary tract infections (UTIs). This technique is particularly valuable in diagnosing acute pyelonephritis (APN) and assessing long-term renal damage. Studies have shown that DMSA scans can confirm the presence of renal scars in a significant number of children with UTIs, helping to localize parenchymal changes and guide management strategies.[28,31,32]
2. **Diethylenetriamine pentaacetic acid (DTPA) and mercaptoacetyltriglycine (MAG3) scintigraphy**: Both DTPA and MAG3 scintigraphy are used for functional renal assessment. These techniques help in evaluating renal perfusion and function, providing detailed images that aid in diagnosing and monitoring congenital renal anomalies. They are particularly useful in cases of vesicoureteral reflux (VUR) and other urinary tract obstructions (Figure 1.). Dynamic renal scintigraphy with MAG3 is noted for its superior image quality and diagnostic accuracy, making it ideal for pediatric patients.[33]

- **Surgical Planning and Postoperative Care**

1. **Role in surgical planning**: Nuclear medicine techniques such as DTPA and MAG3 scintigraphy are essential in the preoperative evaluation and planning of surgeries involving renal anomalies and obstructions.[34–36] These imaging modalities provide crucial information on renal function and perfusion, allowing surgeons to assess the extent of the condition and plan the appropriate surgical intervention. For instance, MAG3 scintigraphy is used to evaluate the function of the renal units before corrective surgeries for ureteropelvic junction obstruction (UPJO), helping to determine the necessity and type of surgical intervention.[36,37]
2. **Monitoring post-surgery outcomes**: Postoperative care and monitoring of renal function are critical to ensuring successful surgical outcomes. DMSA, DTPA, and MAG3 scintigraphy are used to monitor the function and recovery of the kidneys after surgery. These techniques help in detecting any complications, such as recurrent obstructions or renal scarring, allowing for timely interventions and adjustments in the treatment plan. Continuous monitoring with these imaging modalities ensures that the kidneys are functioning optimally and helps in managing any long-term sequelae of the surgical procedures.[38]

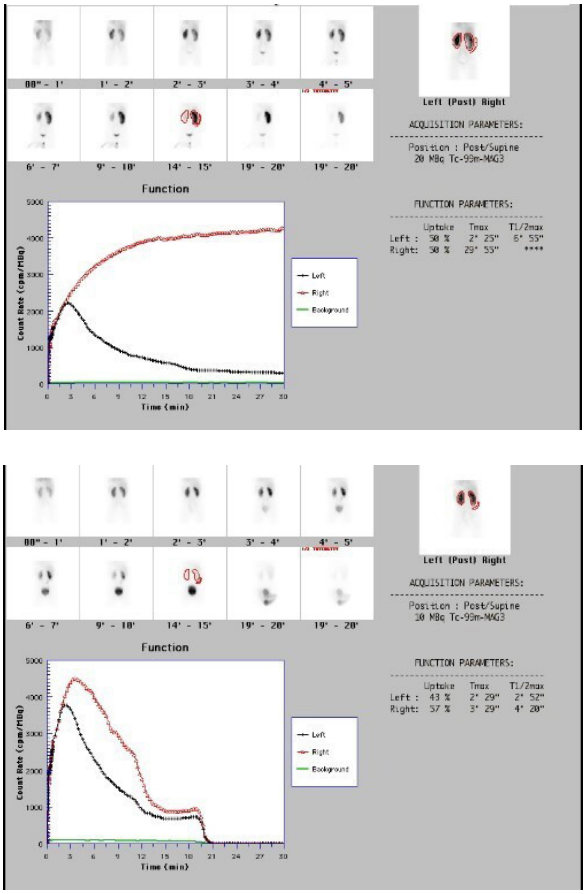

Figure 1. Roi curve showing the functional change after imaging with MAG3 scintigraphy before and after surgery in a 4-year-old girl diagnosed with vesicoureteral reflux. Image on the left before surgery, image on the right after surgery (from the archive of Prof. Dr. Ünal Bıçakcı; Ondokuz Mayıs University Faculty of Medicine Department of Pediatric Surgery and Division of Pediatric Urology).

SPECT/CT INTEGRATION

Enhanced Imaging

The integration of single-photon emission computed tomography (SPECT) with computed tomography (CT) in dimercaptosuccinic acid (DMSA) scintigraphy significantly enhances diagnostic accuracy and reader confidence in pediatric renal assessments.

1. **Improved diagnostic accuracy**: SPECT/CT provides a hybrid imaging technique that combines functional and anatomical data, offering superior diagnostic capabilities compared to planar imaging alone. This integration allows for precise localization and characterization of renal lesions, improving the detection and evaluation of renal cortical defects and

scarring. For instance, a study on patients with sickle cell disease demonstrated that SPECT/CT with DMSA was more effective in identifying cortical lesions compared to planar imaging, with lesions clearly identified only on SPECT images in 52% of cases.

2. **Enhanced anatomical detail**: The combination of SPECT and CT provides detailed anatomical context to functional imaging, allowing for better differentiation between renal parenchymal abnormalities and other structures. This enhanced detail helps in accurately diagnosing conditions such as renal scars, infections, and other abnormalities. SPECT/CT has been shown to identify renal lesions, prominent renal columns, and increased renal size, offering comprehensive insights into renal morphology and function.[39]
3. **Increased reader confidence**: The integration of SPECT/CT improves reader confidence by providing clearer and more detailed images, reducing uncertainty in interpreting complex cases. The ability to visualize functional data in conjunction with high-resolution anatomical structures allows for more accurate and confident diagnoses. This is particularly beneficial in pediatric patients, where precise diagnosis is crucial for effective management and treatment planning. For example, SPECT/CT was found to enhance the interpretation of radionuclide shunt studies by clearly demonstrating activity accumulation and identifying obstructions that were not evident on planar images alone.[40]

Limitations and Considerations

Radiation Exposure

Concerns related to radiation exposure: Radiation exposure is a significant concern in pediatric patients undergoing scintigraphy due to their increased sensitivity to radiation and the potential long-term risks associated with cumulative exposure. Minimizing radiation dose is crucial to reduce the risk of radiation-induced damage, especially in young children whose tissues and organs are more susceptible to radiation.

Measures to Minimize Radiation Exposure

1. **Dose optimization:** Using the lowest effective dose of radiopharmaceuticals is essential. Pediatric radiopharmaceutical doses are often calculated based on body weight or surface area to ensure that the radiation dose is as low as reasonably achievable (ALARA) while still obtaining diagnostic quality images.[2]
2. **Advanced imaging techniques:** Incorporating advanced imaging techniques such as SPECT/CT can enhance diagnostic accuracy, potentially reducing the need for repeat scans. The combined functional and anatomical imaging provided by SPECT/CT allows for more precise localization and characterization of renal lesions, thereby improving diagnostic confidence and reducing unnecessary additional imaging.[39]
3. **Shielding and protective measures:** Implementing appropriate shielding and protective measures during imaging procedures can further minimize radiation exposure to non-targeted areas of the body. Ensuring that only the area of interest is exposed to radiation and using lead aprons or other protective devices can help protect other body parts from unnecessary radiation.[41]

Future Directions and Research

Technological Advancements

Potential advancements in nuclear medicine:

1. **Hybrid imaging techniques:** The integration of SPECT/CT and PET/MRI is expected to enhance the diagnostic accuracy and detail of pediatric renal imaging. These hybrid modalities provide comprehensive functional and anatomical information, facilitating more precise diagnoses and treatment plans. The use of PET/MRI, although currently less common, offers significant potential due to its superior soft-tissue contrast and lower radiation dose compared to PET/CT.[42]
2. **Artificial intelligence and machine learning:** The integration of artificial intelligence (AI) and machine learning (ML) in nuclear medicine can revolutionize image analysis and interpretation. AI algorithms can assist in detecting subtle abnormalities, quantifying renal function, and predicting outcomes, thereby improving the accuracy and efficiency of diagnoses. These technologies also hold promise for personalized medicine by tailoring diagnostic and therapeutic approaches to individual patient profiles.[43]

New radiotracers and molecular imaging: The development of new radiotracers and molecular imaging agents can provide more specific and sensitive detection of renal pathologies. Targeted tracers designed for specific renal receptors or metabolic pathways can enhance the detection of early disease stages and monitor therapeutic responses more effectively. The concept of theranostics, combining diagnostic and therapeutic capabilities in a single agent, is also gaining traction, offering personalized treatment options.[44]

DISCUSSION

Nuclear medicine techniques such as Tc-99m DMSA, Tc-99m DTPA, and Tc-99m MAG3 scintigraphies play an indispensable role in pediatric nephro-urology, providing critical diagnostic and management tools. Each of these techniques offers unique advantages and comes with certain limitations, making it important to choose the appropriate modality based on the clinical scenario.

Advantages and Disadvantages of DMSA Scintigraphy

Advantages

1. **High sensitivity and specificity:** DMSA scintigraphy is the gold standard for detecting renal cortical scarring and assessing functional renal parenchymal damage. It surpasses ultrasound in sensitivity and specificity, making it indispensable for early detection and monitoring of renal scars resulting from recurrent UTIs or pyelonephritis.[5]

2. **Detailed renal cortical imaging**: The high-resolution images provided by DMSA scans allow for precise identification of focal and global renal parenchymal defects, which is crucial for accurate diagnosis and effective treatment planning.[2]
3. **Non-invasive and safe:** DMSA scintigraphy is minimally invasive and involves low radiation exposure, making it a safe and repeatable method for pediatric patients.[8]

Disadvantages

1. **Radiation Exposure:** Despite being low, radiation exposure remains a concern, especially for repeated scans over time. Efforts must be made to minimize radiation dose while maintaining diagnostic accuracy.[45]
2. **Limited functional information:** While excellent for anatomical details, DMSA scintigraphy provides limited functional information compared to techniques like DTPA and MAG3, which can assess renal perfusion and function.[2]

Advantages and Disadvantages of DTPA Scintigraphy

Advantages

1. **Assessment of GFR:** DTPA scintigraphy is ideal for measuring GFR, providing quantitative data essential for diagnosing and monitoring renal conditions such as obstructive uropathy and renal artery stenosis.[15]
2. **Effective in evaluating renal perfusion:** DTPA scans offer detailed insights into renal blood flow and perfusion, helping to identify perfusion defects and renal ischemia.[19]
3. **Non-invasive and safe:** Similar to DMSA, DTPA scintigraphy is minimally invasive with low radiation exposure, making it suitable for pediatric use.[18]

Disadvantages

1. **Radiation exposure:** Although low, the cumulative radiation dose can be a concern, particularly in pediatric patients requiring multiple scans.[45]
2. **Less detailed anatomical imaging:** Compared to DMSA, DTPA provides less detailed anatomical information, which can be a limitation when precise localization of defects is needed.[2]

Advantages and Disadvantages of MAG3 Scintigraphy

Advantages

1. **Dynamic imaging capability:** MAG3 scintigraphy excels in dynamic renal imaging, particularly useful in assessing conditions like ureteropelvic junction obstruction (UPJO) and other obstructive uropathies.[23]
2. **Superior image quality:** MAG3 provides high-quality images even in patients with impaired renal function, due to its higher extraction efficiency, which results in clearer and more reliable images.[21]
3. **Non-invasive and safe:** MAG3 scintigraphy, like DMSA and DTPA, is non-invasive and involves low radiation exposure, making it safe for repeated evaluations.[23]

Disadvantages

1. **Radiation exposure:** Despite being low, the radiation dose must be carefully managed, especially in children who are more sensitive to radiation.[45]
2. **Availability and cost:** The advanced technology and radiotracers required for MAG3 scintigraphy can be more costly and less widely available compared to other techniques.[46]

CURRENT TRENDS AND FUTURE DIRECTIONS

Recent advancements in hybrid imaging techniques, such as the integration of SPECT/CT and PET/MRI, promise to enhance the diagnostic accuracy and detail of pediatric renal imaging by combining functional and anatomical data. This hybrid approach allows for precise localization and characterization of renal lesions, improving the overall diagnostic process. Additionally, the integration of artificial intelligence (AI) and machine learning (ML) in nuclear medicine can revolutionize image analysis and interpretation, leading to more accurate and efficient diagnoses.[42,43]

CONCLUSION

Nuclear medicine plays a crucial role in pediatric nephro-urology, offering essential diagnostic and management tools for various renal conditions. Techniques such as Tc-99m DMSA, Tc-99m DTPA, and Tc-99m MAG3 scintigraphies provide detailed anatomical and functional insights with minimal invasiveness, making them ideal for use in children.

DMSA Scintigraphy is highly sensitive and specific for detecting renal cortical scarring and parenchymal damage, crucial for managing recurrent UTIs and pyelonephritis. It remains the gold standard for evaluating renal defects, outperforming other imaging modalities like ultrasound.

DTPA Scintigraphy is valuable for assessing glomerular filtration rate (GFR) and renal perfusion. It provides quantitative data essential for diagnosing and monitoring renal conditions such as obstructive uropathy and renal artery stenosis.

MAG3 Scintigraphy excels in dynamic renal imaging, especially in cases of impaired renal function. It offers superior image quality and diagnostic capability, particularly for conditions like ureteropelvic junction obstruction (UPJO) in children.

The integration of SPECT/CT enhances diagnostic accuracy by combining functional and anatomical data, improving the detection and evaluation of renal defects and scarring.

While radiation exposure is a concern, measures like dose optimization, advanced imaging techniques, and protective measures help minimize risks, especially in pediatric patients.

Future advancements in nuclear medicine, such as hybrid imaging techniques, artificial intelligence, and new radiotracers, promise to further enhance diagnostic precision and treatment efficacy.

Contribution to the scientific community: This review underscores the indispensable role of nuclear medicine in

pediatric nephro-urology, highlighting the strengths and limitations of various scintigraphy techniques. By providing a comprehensive overview of the applications and advantages of Tc-99m DMSA, DTPA, and MAG3 scintigraphies, this paper aids clinicians in selecting the most appropriate diagnostic tool based on specific clinical scenarios. The discussion on recent technological advancements and future directions in nuclear medicine offers valuable insights for ongoing research and clinical practice, aiming to improve patient outcomes and quality of care in pediatric nephro-urology

ETHICAL DECLARATIONS

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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