

The Role of ^{99m}Tc-DTPA Dynamic Renal Scintigraphy in the Management of Urinary Tract Stones in Senegal: A Study of 88 Cases at the Nuclear Medicine Department of Idrissa Pouye General Hospital

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ABSTRACT

Introduction: Urinary lithiasis is one of the most common obstructive uropathies in men, affecting approximately 1% of the male population. It is more prevalent in hot countries and those with a high standard of living. Dynamic renal scintigraphy with a hyperdiuresis test allows for the estimation of individual kidney function and the evaluation of urine flow, thus assessing the severity of the obstruction. Our objective was to evaluate the role of dynamic renal scintigraphy in the management of urinary lithiasis in Senegal. **Methods:** This was a retrospective study of the records of patients with urinary stones who underwent dynamic renal scintigraphy with ^{99m}Tc-DTPA at the Nuclear Medicine Department of HOGIP between 2010 and 2017. **Results:** We collected 88 records, with upper urinary tract stones accounting for 39.77%. The average age at diagnosis of urinary stones was 45 years. There was an overall male predominance. The circumstances of discovery were primarily clinical signs, with abdominal pain followed by signs of urinary tract infection being the most common presentation. The most frequently used paraclinical examinations for the diagnosis, management, and follow-up of these conditions were urinary tract ultrasound, CT urography, and dynamic radionuclide imaging. Ultrasound allowed us to diagnose urinary tract stones in 65.71% of cases. CT urography revealed a stone in the urinary tract in 82.86%. Management was primarily surgical, guided by dynamic renal scintigraphy. Data from dynamic renal scintigraphy with ^{99m}Tc-DTPA yielded the following results: T_{max} was prolonged in 64.86%; NORA showed partial drainage in 36.49% and poor drainage in 17.57%; VFR was abnormal in 48.65%, of which 66.67% were hypofunctional and 33.33% were silent; the obstruction was organic in 45.95%, functional in 40.54%, and normal in 13.51%. **Conclusion:** Renal scintigraphy with ^{99m}Tc-DTPA and furosemide stimulation has overcome the limitations of morphological imaging techniques in distinguishing between organic and functional obstruction, thus contributing to improved therapeutic management at a favorable dosimetric cost.

Keywords: dynamic renal scintigraphy, organic-like obstruction, functional-like obstruction.

1. Introduction

Obstructive uropathies are caused by an anatomical or functional obstruction to normal urinary flow, sometimes leading to obstructive nephropathy. They can affect the kidney, the urinary tract (ureters, bladder, urethra), or the genital organs (6).

Urological conditions, due to their multiple acquired and especially congenital or malformative etiologies, occur at all ages. However, ureteropelvic junction obstruction (UPJ) and urolithiasis

are the most common causes, compared to tumor compression, trauma, post-radiation stenosis, ureteral stenosis, megaureter, and congenital dilatation (6, 8). Nowadays, numerous imaging techniques exist for examining the urinary tract. These include ultrasound, retrograde urethrography (RUG), retrograde ureteropyeloplasty (RUP), computed tomography (CT), magnetic resonance imaging (MRI), and scintigraphy (5; 8; 11).

These techniques most often allow for confirmation of the diagnosis, assessment of the impact on renal function, guidance and monitoring of treatment, and informing patients about the prognosis and potential long-term effects of the condition.

Among these imaging modalities, ultrasound, CT urography, and radioisotope examinations play a significant role in both diagnosis and treatment (6; 11). Radioisotope imaging provides functional and morphological information in the context of major urological and nephrological syndromes (1). Optimizing this information requires knowledge of the kidney's specific characteristics and the methodological principles of these examinations. Dynamic renal scintigraphy (DRS) with furosemide sensitization helps differentiate between an organic or functional obstruction to urinary flow and simple dilation without underlying obstruction. ^{99m}Tc -DMSA scintigraphy assesses the impact on the upper urinary tract by detecting lesions and sequelae of pyelonephritis.

These radioisotope examinations are non-invasive, involve low radiation exposure, and constitute an essential tool in the diagnostic and therapeutic management of obstructive uropathies.

2. Materials and Methods

2.1 Study Setting

Our study was conducted in the nuclear medicine department of the Idrissa Pouye General Hospital (HOGIP). Operational since June 2009, the HOGIP nuclear medicine department is the only currently functioning reference service of its kind in Senegal.

2.2 Study Type and Population

We conducted a retrospective, descriptive, and analytical study of the records of patients with obstructive uropathy (pulmonary stenosis and/or kidney stones) who underwent dynamic renal scintigraphy with ^{99m}Tc -DTPA at the Nuclear Medicine Department of HOGIP, between January 2010 and December 2017.

2.3 Data Collection and Analysis

2.3.1 Data Collection

To collect the data, we used:

- The physical records (clinical observation sheets) of each patient included in the study, both in the nuclear medicine department and in their originating department.
- All dynamic renal scintigraphy images recorded during the study period were reviewed.

For each record, the data were transcribed onto the data collection form designed for the study.

2.3.2 Data Analysis

Data entry and processing were performed using Epi Info software under Windows 10.

The renal scintigraphy data were compared with the clinical, paraclinical (ultrasound and CT urography), therapeutic, and outcome parameters of our patients.

Figures and diagrams were created using Microsoft Office Excel.

2.4 Variables Studied

2.4.1 Dependent Variables

The dependent variables in our study were the results of the dynamic renal scintigraphy.

2.4.2 Independent Variables

The variables that were independent of our study were:

- Epidemiological data: age, sex
- Indication for renal scintigraphy
- Time between diagnosis of obstructive uropathy and performance of renal scintigraphy

- Circumstances of disease discovery
- Results of radiological assessment (abdominal ultrasound, CT urography)
- The therapeutic approach adopted (observation, medical and/or surgical treatment and/or monitoring).

2.5 Procedure for the scintigraphic examination

2.5.1 Technique

All our patients underwent dynamic renal scintigraphy with ^{99m}Tc-DTPA, performed after intravenous bolus injection of an average activity level based on weight and age.

The dynamic acquisition was conducted over a period of 31 minutes in two phases:

- A vascular phase (or angiography), lasting 60 seconds with 60 sequential 1-second images, recorded with a 64x64 matrix, during which the first vascular passage of the radioactive embolus was recorded.

-A parenchymal (or nephroscintigraphic) phase of 30 minutes with 60 sequential images of 20 seconds each, a matrix of 128x128, during which the phenomena of accumulation (uptake) then decrease of the tracer (washout) predominate.

Preparation for the examination consisted of adequate prior hydration of the patient. When possible, the patient was asked to urinate just before the examination to minimize interference from bladder fullness. The patient was positioned supine, with the detector positioned over the lumbar region. Restraint was used, particularly in young children or when the child was agitated.

The dynamic scintigraphic examination was supplemented, if necessary, by a static acquisition of a one-minute post-void image in a posterior view. This provided information on the quality of bladder emptying (looking for any post-void residual urine) and, most importantly, assessed the presence or absence of any residual activity in the area of both kidneys. A furosemide hyperdiuresis test was performed on all patients. Furosemide was injected into our patients according to the F+20 protocol, i.e., 20 minutes after injection of the radiotracer at a dose of 1 mg/kg (without exceeding a maximum dose of 20 mg).

After digital processing of the sequential images recorded following manual tracing of renal ROIs and background noise, the scintigraphy was interpreted according to:

-Qualitative criteria: based on a visual assessment of the intra- and extrarenal transit of the tracer.

-Semi-quantitative criteria: based primarily on the analysis of the obtained isotopic nephrograms and their interpretation parameters, mainly: time to maximum activity (Tmax) and normalized residual activity (NORA).

-Quantitative criteria: evaluating the relative contribution of each kidney to glomerular filtration rate or separate renal function.

2.5.2 Equipment and Procedures

The scintigraphic examination was performed using a wide-field gamma camera equipped with a low-energy, high-resolution parallel collimator.

The renal scintigraphy data were compared with the clinical, paraclinical (ultrasound and CT urography), therapeutic, and follow-up parameters of our patients.

3. Results

3.1 Epidemiological data

3.1.1 According to obstructive uropathy

Of the 88 patients included in our study, 35 patients, or 39.77%, had urinary lithiasis.

3.1.2 Age

The average age of patients was 45 years, the most represented five-year age groups were 55-60 years and 60 and over.

3.1.3 Sex

The distribution of patients by sex showed an overall male predominance with 68.57% men.

3.2. Clinical data on urinary lithiasis

In our study, the most frequently observed clinical signs of urinary lithiasis were abdominal pain in 24 cases (68.58%), followed by signs of urinary tract infection in 9 cases (25.71%).

3.3 Paraclinical data (N=88)

The paraclinical examinations performed were:

- Dynamic renal scintigraphy in 100% of cases
- Ultrasound and CT urography results were obtained in 77.30% of patients each.

3.3.1 Abdominal ultrasound (N=68)

Abdominal ultrasound results were available for 68 patients (77.30%) and revealed:

- Of the 35 patients presenting with signs of renal colic, ultrasound visualized a stone in 23 cases (65.71%), including 11 bilateral cases (47.83%) and 12 unilateral cases (53.17%): 8 on the left and 4 on the right.

3.3.2 Uro-CT scan (N=68)

Urine CT scans were available for 68 patients (77.30%) and revealed:

- A kidney stone in 29 patients (82.86%), including:
 - 26 unilateral cases (9.66%), with 13 cases (44.83%) located on both the right and left sides.
 - 3 bilateral cases (10.34%).

3.3.3 Dynamic Renal Scintigraphy with ^{99m}Tc -DTPA (N=88)

3.3.3.1 Injected Radiotracer Activity

The mean injected activity in our patients was 4.73 mci, with a range of 2.46 mci to 9.15 mci.

The 4-5 mci and 5-6 mi radiotracer dose ranges were the most frequent, occurring in 41.40% and 35.80% of patients, respectively.

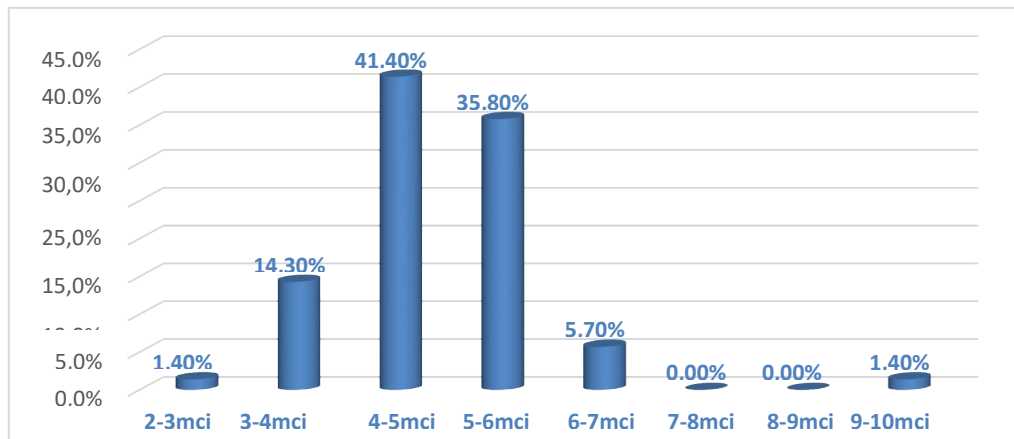


Figure 1: Distribution of injected radiotracer activity.

3.3.3.2 Interpretation of results

The parameters for interpreting dynamic renal scintigraphy were essentially:

- Maximum time (Tmax, peak uptake): This should normally occur between the third and sixth minute.
- Normalized residual activity (NORA): This should be less than 100% (normal emptying), partial emptying between 100 and 200%, and poor emptying if greater than 200%.
- Relative renal function (RRF): The separate renal function, which is normal when between 43 and 57%.

These parameters allowed us to classify the results of the radioisotope nephrograms (N = 74) of our patients as follows:

- The Tmax was prolonged in 48 kidneys (64.86%), and normal in 26 kidneys (35.14%).
- Noral renal artery drainage (NORA) showed good drainage in 34 kidneys (45.94%), partial drainage in 27 kidneys (36.49%), and poor drainage in 13 kidneys (17.57%).
- The renal function potential (RFP) was normal in 38 kidneys (51.35%), abnormal in 36 cases (48.65%), including 24 kidneys (66.67%) with a hypofunctioning kidney (7 cases with an RFP between 10% and 20%; 17 cases between 20% and 45%) and 12 (33.33%) with non-functioning kidneys.

The nature of the stasis was:

- Organic in nature, unresponsive to Lasix in 34 cases (45.95%), with a right-sided predominance (15 cases), 13 left-sided cases, and 3 bilateral cases.
- Functional in nature, responsive to Lasix in 30 cases (40.54%), with a right-sided predominance (11 cases), 9 left-sided cases, and 5 bilateral cases.
- The urine expression was normal in 10 cases (13.51%).

Some clinical cases illustrating our results are presented in Observations 3, 4, and 5.

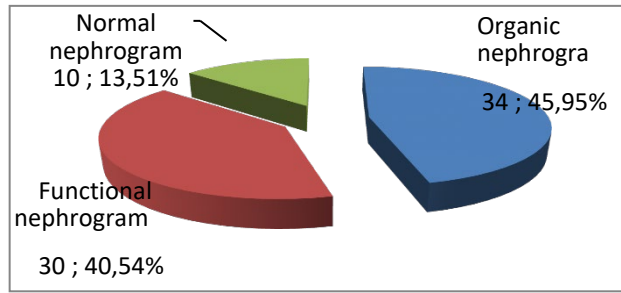


Figure 2: Distribution of patients according to the appearance of the isotopic nephrogram.

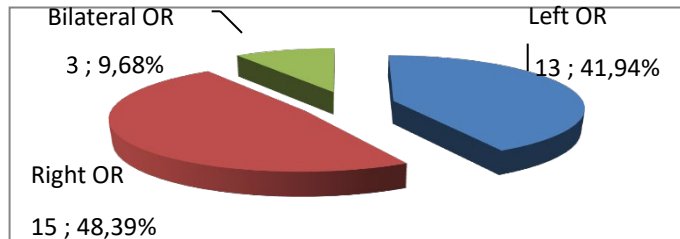


Figure 3: Distribution according to the location of organic-looking retentions.

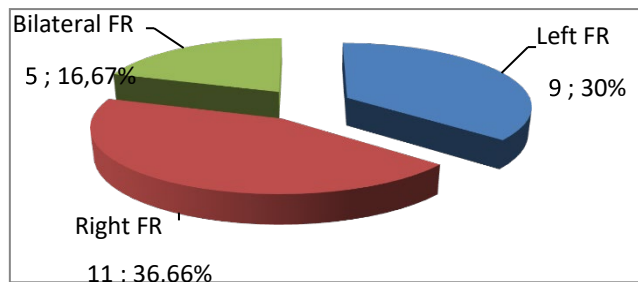


Figure 4: Distribution according to location of functional-looking retentions.

3.3.3.3 Time to scintigraphy (N=88)

The mean time between the date of diagnosis of obstructive uropathy and the date of renal scintigraphy was 28.33 months, with a range from 1 month to 30 years and 5 months.

The most represented age group was 1 month–1 year (47,00%), followed by the 1–2 year, 2–3 year, and 10 years and older age groups (10.00%).

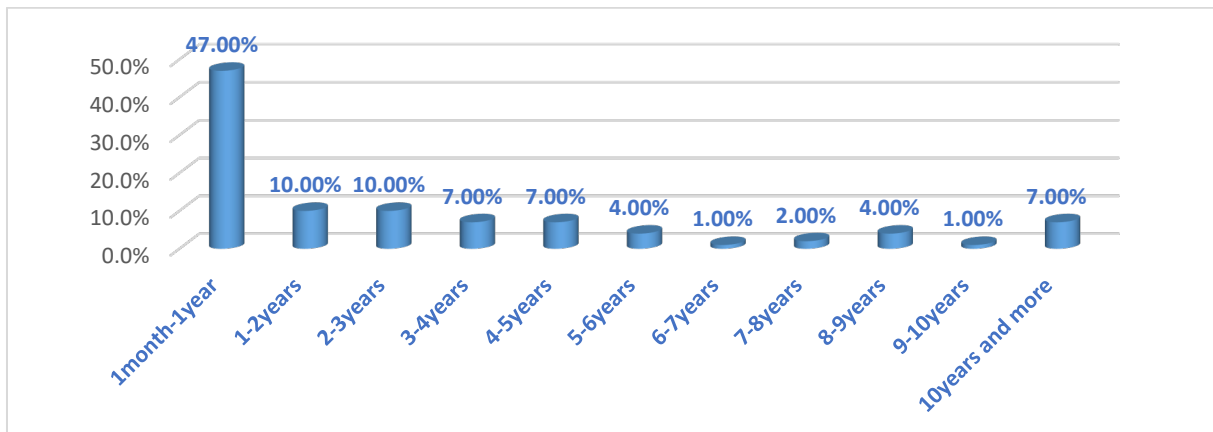


Figure 5: Distribution of patients according to the time elapsed between the date of diagnosis of kidney stones and the renal scintigraphy.

3.3.3.4 Follow-up Scintigraphy (N=2)

In our study, only 2 patients underwent a follow-up scintigraphy. One patient showed a marked improvement in glomerular filtration rate on the follow-up scan, and the other's follow-up results were almost identical to the first.

3.4 Treatment Characteristics

In our study, the treatment received by the patients was:

- 87 cases (98.86%), surgical treatment
- 1 case (1.14%), therapeutic abstention with monitoring.

The type of surgical treatment received was:

- Placement of a double JJ stent in 6 cases (21.43%)
- Placement of a JJ stent followed by nephrectomy in 4 cases
- Pyeloplasty in 5 cases
- Placement of a JJ stent followed by pyeloplasty in 3 cases
- Nephrostomy in 4 cases
- Placement of a JJ stent followed by nephrostomy in 3 cases
- Nephrectomy followed by contralateral pyeloplasty in 2 cases (2.35%)
- Nephrostomy followed by contralateral pyeloplasty in 1 case.

For the 2 patients with kidney stones in the upper urinary tract, one underwent placement of a JJ stent followed by nephrectomy, and the other underwent placement of a JJ stent and contralateral pyeloplasty.

4. Discussion

➤ According to obstructive uropathy

Obstructive uropathy is caused by an anatomical or functional obstruction to normal urinary flow, sometimes leading to renal dysfunction. Its prevalence depends on the cause and varies between 5 per 10,000 and 5 per 1,000. The condition has a bimodal distribution. In childhood, it is primarily due to congenital malformations of the urinary tract. The incidence then decreases after age 60, before increasing again, particularly in men (Durand E, 10; Ndong B. et al., 15).

While the epidemiology of kidney stones is defined by the socioeconomic level and the degree of medical access in the population (Daudon, M. et al., 9).

➤ According to age

The age at which obstructive uropathies are diagnosed has changed in recent years thanks to advances in prenatal diagnosis and undoubtedly to the widespread use of obstetric ultrasound.

In our study, the average age at diagnosis of kidney stones was 45 years. Indeed, this condition is most often discovered at a young age. Our results are almost identical to those of Ndong B. (15) in the same department, where the average age of patients was 41 years; as well as those of Prince PH. et al., where the patients' ages ranged from 15 to 45 years.

➤ According to sex

In our study, this male predominance was also found in urinary stones, representing 68.57% of cases. These results are consistent with those of Leroy V. et al. (14), who found a sex ratio of 1.7 in Senegal; Coulibaly M. et al. (8) 1.32; Alaya A. et al. (3) 1.47 in children

➤ **According to the signs at the time of discovery of urinary stones**

In our study, abdominal pain was found in 68.58% of cases, followed by signs of urinary tract infection in 25.71%. Our results appear to confirm those of the study by Ndong B. (15) in the department where pain was the most frequent clinical sign in 91% of patients, and in 64% of cases, it was of the renal colic type. Similarly, Alaya A. et al. (3) reported that the circumstances of discovery were dominated by abdominal pain in 37.1%, hematuria in 33.7%, and urinary tract infection in 30.7%.

Adambounou.K et al. (1) found abdominal pain in 28% and gross hematuria in 23% in a pediatric study.

In contrast, the study by Alaya A. et al. (3) in school-aged children refuted these results, finding hematuria in 37.9% of patients, urinary tract infection in 36.4%, and abdominal pain in 30.7%.

➤ **Based on imaging data:**

Abdominal X-ray (AXR) and ultrasound remain the first-line examinations for lumbar fossa symptoms. They aid in diagnosis by confirming the diagnosis and allow for the assessment of the corticomedullary index.

In our series, no AXR was performed, demonstrating the increasing neglect of this examination, which remains highly valuable in abdominal symptomatology.

Abdominal ultrasound: Ultrasound remains a reliable examination for detecting dilation of the renal pelvis and calyces.

Ultrasound also allowed visualization of a kidney stone in 65.71% (23/35), including 47.83% bilateral (11/23) and 53.17% unilateral (12/23), with a left-sided predominance (8/12). Our results are identical to those of Daudon M. et al. (9) and Benchoux M. (5), who found a predominance of kidney stones in the left kidney.

Ultrasound allows us to see the presence or absence of stones in the renal tree and to assess the renal impact of the stone.

However, it remains a very useful complementary examination in the investigation of abdominal symptoms, as it allows us to clarify the diagnosis of hydronephrosis, determine whether the condition is unilateral or bilateral, identify the presence or absence of stones, and assess corticomedullary differentiation. But nowadays, it is increasingly combined with CT scanning.

➤ **CT urography**

In our study, CT urography allowed us to diagnose kidney stones in 82.86% of cases, of which 89.66% were unilateral (44.83% on the right and 44.83% on the left) and 10.34% were bilateral.

These results are consistent with those of Benchoux M. (5), where kidney stones were diagnosed in 73.4% of patients, of which 70.4% were unilateral (39.1% on the right side and 31.3% on the left).

➤ **injected radiotracer activity**

In our series, the average dose of injected radiotracer in our patients was 4.73 mCi in adults.

➤ **Results of ^{99m}Tc-DTPA Dynamic Renal Scanning (DRS)**

The results of ^{99m}Tc-DTPA dynamic renal scintigraphy allowed us to classify our patients according to the two major pathologies studied, representing 39.77% of cases:

The T_{max} was prolonged in 64.86%, with values ranging from 6.20 minutes to 40 minutes, and normal in 35.14%. This is due to the slow uptake caused by dilation of the renal pelvis and calyces secondary to obstruction by the kidney stone.

NORA showed good drainage in 45.94%, partial drainage in 36.49%, and poor drainage in 17.57%. These results help guide clinicians in patient treatment, particularly in making surgical decisions.

The renal flow velocity (RFV) was normal in 51.35%, abnormal in 48.65%, with values ranging from 0% to 43%, including 66.67% hypofunctional cases (70.83% above 20% and 29.17% below 20%); 17 cases, or 33.33%, were non-functioning kidneys.

The RFV of the diseased kidney was abnormal in 48.65%, possibly due to renal parenchymal destruction secondary to the stone.

Overall, we noted an absence of obstruction in 13.51% of cases, organic-like stasis in 45.95%, with a right-sided predominance in 44.12% compared to 38.24% on the left and 17.64% bilateral. A functional-type stasis in 40.54% with a right predominance in 36.66% against 30% on the left and 33.34% bilateral.

➤ **Time to renal scintigraphy (N=88)**

The average time to renal scintigraphy after diagnosis of obstructive uropathy was very long, 28.33 months for urinary stones. This can be explained by the fact that scintigraphy has only been available in Senegal in recent years and intermittently, although with some improvement since 2018. It should also be noted that there is currently only one functional nuclear medicine department for the entire country of Senegal.

➤ **Follow-up renal scintigraphy (N=2)**

In our series, only two patients underwent postoperative isotopic verification despite requests from their treating physicians. This can be explained, on the one hand, by the high cost of the examination and, on the other hand, by the long waiting time for obtaining the scintigraphy scan due to appointments being scheduled far in advance, linked to problems ordering the reagent from abroad.

Despite these issues, we observe a marked and increasing number of scintigraphic examinations, demonstrating the considerable contribution of this examination to therapeutic management.

➤ **Therapeutic Characteristics**

The determination of renal functional abnormalities is emerging from the development of morphological imaging techniques such as ultrasound and CT urography. This highlights the value of dynamic scintigraphy with ^{99m}Tc-DTPA and a furosemide hyperdiuresis test. This technique serves as a physio-functional exploration tool to more precisely assess the quality of pyeloureteral patency while specifying the relative contribution of each kidney to glomerular filtration rate. Such information remains invaluable for guiding therapeutic management towards surgical, endoscopic, or medical treatment, or even towards therapeutic abstention with close and well-defined monitoring. In our series, dynamic renal scintigraphy with ^{99m}Tc-DTPA and furosemide hyperdiuresis testing helped guide treatment decisions in all patients and led to surgical treatment (radical and conservative) in 98.86% of obstructive uropathies.

The study by Cachat F. et al. (6) demonstrated open surgery as the treatment of choice.

Leroy V. et al. (14) reported in their study that treatment was always surgical and generally conservative; the study by Ndong B. (15) showed that treatment was essentially surgical, with cystolithotomy being the predominant approach.

In contrast, the studies by Cachat I. et al. (6) and Chatti K. et al. (7) highlighted the importance of endoscopic treatments and extracorporeal shock wave lithotripsy (ESWL). However, these techniques are not without risk of failure, sometimes requiring surgical intervention such as JJ stent placement or nephrostomy (Ghfir X. et al (12)).

Conclusion:

Dynamic renal scintigraphy with hyperdiuresis testing allows for the estimation of each kidney's function and the evaluation of urine flow, thus assessing the severity of an obstruction. It can be performed at birth, but it is preferable to wait until the first month of life due to the low glomerular filtration rate in newborns during the first few weeks. Scintigraphy has the dual purpose of defining the impact of urinary tract obstruction on renal function and evaluating the extent of the obstruction to urine flow. In borderline cases, it should be repeated during the first few months of life, sometimes rapidly.

Dynamic renal scintigraphy (DRS) with ^{99m}Tc-DTPA and a furosemide hyperdiuresis challenge serves as a non-invasive, low-radiation physio-functional diagnostic tool for assessing the patency of the excretory urinary tract, particularly the pyeloureteral tract, while also allowing for the evaluation of each kidney's relative contribution to glomerular filtration rate. Such information is essential for guiding therapeutic management, whether radical or conservative surgical intervention, or even therapeutic abstention with close and standardized monitoring. ^{99m}Tc-DTPA renal scintigraphy with a furosemide challenge has overcome the limitations of morphological imaging techniques in distinguishing between organic and functional stasis, thus contributing to improved therapeutic management at a favorable dosimetric cost.

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