Fast, Simple and Easy Renal Protocol for All Indications

$^{99m}$Tc- MAG$_3$ with zero time injection of Furosemide ($\text{MAG}_3$-$F_0$) : A Seventeen Year Experience

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University of Miami School of Medicine
Diuretic Renal Scintigraphy

Indications for the Old (Sophisticated) Protocol

a) Rules Out Obstruction
b) Evaluates Renal Function

The New Fast, Simple and Easy Protocol

a) Helps establish the correct **Diagnosis** for **Vascular, Parenchymal, or Drainage Disorders**

b) Provides **Prognostic Information**

c) Evaluates more accurately **Renal Function**
CLINICAL INFORMATION OBTAINED FROM RENAL SCINTIGRAPHY

• **Morphologic and Functional Information**(regional/global)
• in All Ages and Functional States including Renal Failure
• For **Congenital or Acquired** diseases including **Transplants**
• Essential for **Diagnosis**, **Prognosis** and **Follow-Up** about:
  • **Renal Blood Flow:**
    First pass study images, Flow Velocity Index quantified
  • **Renal Parenchyma:**
    Focal and global diseases visualized, Global Function quantified
  • **Intra/Extra-Renal Drainage System:**
    Morphologic changes visualized, Drainage quantified
• **Technically Easy/ Safe/Acceptable/Affordable**
CLINICAL STATUS of Renal Scintigraphy

Issues:

• Limitations (tumors, stones, calcifications, resolution)
• Complexity of Protocols (old, “sophisticated” protocols)
• Many different Imaging Radiopharmaceuticals
• Unfamiliarity among referring and user doctors
• Correlative Imaging Modalities (U/Sound, CT, MRI)

As a result renal scintigraphy is underutilized
Old “Sophisticated” Protocols for Renal Scintigraphy

We call old “Sophisticated” Renal Protocols the traditional methods of Diuretic Renal Scintigraphy with Bladder Catheterization and injection of Diuretic 20-30+ min post radiopharmaceutical.

These traditional methods were inspired before U/S, CT, MRI were introduced. They were proposed by the experts in the field of renal imaging at the time, were endorsed by the Societies (SNM, Pedi Fetal etc) but never revisited and are still followed by many laboratories (due to lack of communication).

Considering the current standards of practice we believe that these protocols serve the Exceptions rather than the Patient Population we currently evaluate.
Problems with the Old “Sophisticated” Protocols for Renal Scintigraphy

- Patient Preparation is **Painful** and potentially **Dangerous**
  (Bladder Catheterization and IV hydration)
- Studies are **Too Lengthy** (40min-60min)
- The radiation **Exposure** to the gonads is high
- Diagnosis for **Cortical (parenchymal) problems** is **not** obtained
- **Prognosis** is **not** usually possible
- **Quantification** of renal function is **not** adequately obtained

As a result renal scintigraphy has always been and still is underutilized
Problems with the Old “Sophisticated” Protocols for Renal Scintigraphy

Father: “Better operate on my child than ask for a nuclear study”

(Testimony of Dr Ricardo Gonzalez, Pedi-Urologist)

Those who practice pediatric nuclear medicine had these concerns since the seventies and eighties
The New Protocol for Renal Scintigraphy

There has always been

a need for a fast, easy, and simple protocol

but changes in patient population

improvements in other renal imaging methods

and economic issues

have made this change mandatory
Recent Improvements in Other Imaging Modalities which threaten the use of the Sophisticated Scintigraphy

- **Ultrasound**
  - Improved Resolution - Doppler
  - Three Dimensional
  - Contrast Agents

- **Computed Tomography**
  - Spiral CT
  - Dynamic Studies with Contrast
  - CT-Angiography

- **Magnetic Resonance Imaging**
  - GFR Contrast Dynamic Studies
  - MR-Angiography
  - MR-Renography
Combined Static-Dynamic MR Urography

Split Renal Function

Urinary Excretion
The New Protocol for Renal Scintigraphy

Therefore there is an immediate need for a new protocol

- fast, simple and easy
- patient and technologist friendly
- to provide information about drainage
- but also about focal and global renal cortical function
- helpful in diagnosis and prognosis
The New Protocol for Renal Scintigraphy

To obtain best results
with the New Protocol
we must use
the Best FDA approved Radiopharmaceutical

and apply the Best Protocol
THE BLOOD SUPPLY TO THE NEPHRON

Renal Artery (A)

pre-glomerular arteriole = afferent (a)

glomerular capillaries (g)

post-glomerular arteriole = efferent (e)

(per) tubular capillary plexus (t)

vein (V)
Glomerular filtration GF is the result of cardiac power (BP)
And it is due to the fact that the lumen of the efferent arteriole Ae is more narrow than the lumen of the afferent arteriole Aa
FUNCTION OF NEPHRON

Renal Blood Flow: 1000 ml/min
Renal Plasma Flow: 600 ml/min (100%)

Renal Artery → Glomerular Filtration Rate: 120 ml/min (20%)

Tubular Reabsorption: 119 ml/min

Tubular Excretion Proximal
Tubular Excretion Distal

Renal Vein

Urine Volume: 1 ml/min
1440 ml/24 hr
RENAL RADIOPHARMACEUTICALS

$^{99m}\text{Tc-MAG}_3$:...........Tubular Excretion (EE = 60%)
Global Dynamic Tubular Function Imaging

$^{123/131}\text{I-o-Hippurate}$:..GF and TE (EE = 80%)
Dynamic ERPF Imaging

$^{99m}\text{Tc-DTPA}$:...........Glomerular Filtration (EE = 20%)
Dynamic Imaging of GFR

$^{99m}\text{Tc-DMSA}$:...........Cortical Fixation(GF and reabsorption)(EE = 5%)
Parenchymal Function Imaging

$^{99m}\text{Tc-GH}$:.............Combined GF and Cortical Fixation (EE = 20%)
Dynamic GF and Parenchymal Imaging
$99m \text{Tc-Mertiatide (MAG}_3\text{)}$

- Renal Artery: 100%
- Glomerular Filtration: 5%
- Tubular Excretion: 55%
- Remaining Activity: 40%
- Extraction Efficiency: 50-60%
- Renal Vein

Counts from Kidney

72% of Dose in Urine at 30 min.

- 0 - 2 min.
- 2 - 4 min.
- 4 - 6 min.
- 10 min.
- 1 hr.
ADVANTAGES of MAG₃ for RENAL SCINTIGRAPHY

• High Renal Extraction Efficiency 60%
  Fast parenchymal accumulation
  Fast background clearance
  Effective Early Parenchymal Imaging
  Accurate evaluation of Intra/Extra Renal Drainage

• Small Distribution Space
  Steep (sensitive) Renograms

• Technetium-99m-Chemical Labeling
  High dose, Good statistics, Low radiation exposure

• Safe (experience 17 years)
COMPARISON BETWEEN $^{99m}$Tc-MAG$_3$ AND $^{123/131}$I-O-HIPPPURATE
MAG₃ ADVANTAGES (v/s DTPA)

MAG₃: TUBULAR EXCRETION IMAGING AGENT WITH HIGH RENAL EXTRACTION EFFICIENCY (60% as compared to DTPA which is 20%)

Renal imaging studies with MAG₃ are:

- Usually diagnostic
- Highly sensitive to function changes
- Substantially disease specific
- Easily quantifiable
- Fast, with low radiation exposure
- Provide information about the cortex

Provide Prognostic Information
## MAG₃ comparison to DTPA

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<tr>
<th>1) FUNCTION</th>
<th>MAG₃ TUBULAR</th>
<th>DTPA GLOMERULAR</th>
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<tr>
<td>Visualize kidney even with no GF (ATN, total obstruction, toxicity):</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Visualize Regional Dysfunction (APN, Focal Nephritic/otic, RVH):</td>
<td>Yes</td>
<td>No</td>
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<th>2) EXTRACTION EFFICIENCY</th>
<th>MAG₃</th>
<th>DTPA</th>
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<tr>
<td>Parenchymal Evaluation (Rejection, Nephrotic, Nephritic etc)</td>
<td>Yes</td>
<td>?</td>
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<tr>
<td>Study of Drainage (Diuretic Renography etc):</td>
<td>Sensitive</td>
<td>Mediocre</td>
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<tr>
<td>Patient Radiation (Radiation exposure of the patient):</td>
<td>Low</td>
<td>High</td>
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COMPARISON OF MAG₃ WITH DTPA
The New Protocol for Renal Scintigraphy

To obtain best results with the New Protocol we must use the Best FDA approved Radiopharmaceutical

Finally it was Recognized to be $^{99m}\text{Tc} - \text{MAG}_3$

and apply the Best Protocol
The New Protocol for Renal Scintigraphy

17 years Experience at the UM,

indicates that \text{MAG}_3\text{-F}_0 \text{ is the protocol, which covers}

most of the current renal imaging needs

for the majority of cases

$^{99m}\text{Tc- MAG}_3$ with zero time injection of Furosemide
The New Protocol for Renal Scintigraphy

To obtain best results with the New Protocol we must use the Best FDA approved Radiopharmaceutical:

Finally it was Recognized to be $^{99m}$Tc - MAG$_3$

and apply the Best Protocol:

$^{99m}$Tc - MAG$_3$ with zero time injection of Furosemide
Basic Principle for the New Protocol: 
(MAG$_3$-F$_0$)

When Lasix is injected IV:
its Diuretic Effect begins between 3 - 5 min
(the maximum effect at 9 min)

Therefore with the F$_0$ injection there is enough time
to study the drainage (4 to 22 = 18 min)

and in addition the parenchyma can be studied
THE FAST PROTOCOL:
It began at OSU and continued at UM first as Hippuran-F$_3$
and when MAG$_3$ became available (1990) as $^{99m}$Tc-MAG$_3$-F$_0$

Fast Protocols for Obstruction (Diuretic Renography) and for Renovascular Hypertension (ACE Inhibition)

George N. Sfakianakis, Michael Georgiou, Felipe Cavagnaro, Jose Strauss, and Jacque Bourgoignie

University of Miami School of Medicine and Jackson Memorial Hospital, Miami, Florida

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VOLUME 20, NUMBER 4, DECEMBER 1992
Diuretic Renal Study: Protocol at UM/JMH

$^{99m}$Tc-MAG$_3$-F$_0$ (or MAG$_3$-F$_0$)

No difficult Patient Preparation is needed

No Sedation (only restriction of motion)

Hydration 5-10 ml/kg water orally at –30 min

No Bladder Catheterization (except in selected cases)

Study either supine or upright
Renal Scintigraphy at UM/JMMC: (MAG$_3$-F$_0$)
Method applied the last 17 years:

FOR NATIVE KIDNEY STUDIES
FOR RENAL TRANSPLANT STUDIES
A) Dynamic Renal Scintigraphy UM/JMMC: (MAG3-F0)

Method applied the last 17 years:

Injection iv 1-10 mCi MAG3 + 40-80 mg LASIX (Furosemide)

SIMULTANEOUS INJECTION OF MAG3 AND LASIX = F0

ACQUISITION:
- FLOW: 1 min (1 frame per 1 sec)
- FUNCTION: 22 min (1 frame per 30 sec)
- POST VOID: 2 min static image (at 25-30 min)
- DELAYED: 2 min static images (at 1 hr)

GROUPING IMAGES:
- FLOW: in 3 sec images
- FUNCTION: in 2 min images

GRAPH GENERATION:
- FLOW/FUNCTION, KIDNEY/CORTEX

QUANTIFICATION:
- FLOW (FVI) FUNCTION (GRAPHS/MADRE)
B. Tomographic (SPECT) study

MAG3 SPECT: A Rapid Procedure to Evaluate the Renal Parenchyma

George N. Sfakianakis and Mike F. Georgiou
Division of Nuclear Medicine, Department of Radiology and Department of Pediatrics, University of Miami School of Medicine/Jackson Memorial Hospital, Miami, Florida

B. Tomographic (SPECT) study

(evaluates Cortical Anatomy in 3D, Ectopias, Split RF)

Injection iv 2-20 mCi  MAG₃  No Lasix needed

Acquisition of the study 4min
QUANTIFICATION

TIME ACTIVITY GRAPHS
(flow/function/drainage)

SPLIT RENAL FUNCTION
(L/R)

GLOBAL RENAL FUNCTION (GRF)
(CLEARANCE)
TIME ACTIVITY GRAPHS OF SCINTIGRAPHY

a) Renal Blood Flow Graph
   1 sec/point for 30-60 sec
   First Pass Renal Perfusion Activity

b) Renogram (Cortical or Kidney including Pelvis)
   30 sec/point for 24 min
   Balance of feed in-uptake-discharge activity
REGIONS OF INTEREST: NATIVE KIDN. AND TRANSPLANTS

for kidneys          for cortex          background 2          background 3

for flow          for kidney          for cortex
FLOW GRAPHS
TIME ACTIVITY

GRAPHS:

KIDNEY GRAPHS

and

CORTICAL GRAPHS

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<th>TIME</th>
<th>PK T0</th>
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<td>3.35</td>
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<td>CRTX-BkTC1</td>
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<td>3.27</td>
<td>19.3</td>
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EVALUATION AND ANALYSIS OF TIME/ACTIVITY GRAPHS (1)

a) Visual Evaluation

b) Sophisticated Mathematical Analysis
   i. Mean Transit Time (Flow)
   ii. Deconvolution Analysis (Renogram)
EVALUATION AND ANALYSIS OF TIME/ACTIVITY GRAPHS (2)

c) Simple Indices
   i. Flow Velocity Index
   ii. OCA (2.5/20), Tpeak, T-1/2, RCA (20/peak)

d) Computer Automation
   i. Neural Networks
   ii. Artificial Intelligence
FLOW GRAPHS
FLOW VELOCITY INDEX
NORMAL GRAPHS

FLOW VELOCITY INDEX = 0.9
RENOGRAMS

RCA AND OCA

**Residual Cortical Activity (Peak < 20 min)**

\[ RCA = \frac{Cr}{C_p} \times 100 \]

**Original Cortical Activity (Peak ≥ 20 min)**

\[ OCA = \frac{Co}{C_p} \times 100 \]
ESTIMATION OF SPLIT RENAL FUNCTION

a) MAG3 - F0 Study: from the 2d minute counts – BK

b) New accurate method with MAG₃ in obstruction

c) MAG₃ SPECT (2d + 3d min data)
QUANTIFICATION OF RENAL FUNCTION

MAG3 Accumulation and Discharge Rate Equivalent

\[ \text{MADRE} = a\left(\frac{K_{\text{Act}}}{BKG}\right) / bRCA \]
QUANTIFICATION OF RENAL FUNCTION

A method was developed to calculate from the MAG₃-F₀ study THE GLOBAL RENAL FUNCTION (GRF) using:

a) The Kidney Uptake/Body Background Activity (at 2 min)

and b) The Residual Cortical Activity (at 20 min)

(Both these parameters are related with the creatinine levels)
QUANTIFICATION OF RENAL FUNCTION

\[ A = la + ra - bBKG \]

The Kidney Uptake/Body Background Activity (at 2 min)

MAG₃-F₀
MAG3 Accumulation and Discharge Rate Equivalent

\[ \text{MADRE} = \frac{A_k}{A_b' \times 2(RCA')} \]

\[ A_b' = (A_T - A_K) \times \left( \frac{\text{ROI}_B}{\text{ROI}_K} - \text{ROI}_K \right) \times \text{BSA} \]

\[ RCA' = (\text{RCA}_L \times SF_L) + (\text{RCA}_R \times SF_R) \]

- \( A_T \) = Activity in body ROI (counts)
- \( A_K \) = Activity in total kidney ROI (counts)
- \( A_B \) = Background activity (counts)
- \( A_B' \) = Corrected background activity (counts)
- \( \text{SF} \) = Split function
- \( \text{ROI}_B \) = Body region of interest (pixels)
- \( \text{ROI}_K \) = Total kidney region of interest (pixels)
- \( \text{ROI}_K' \) = Total kidney region of interest (pixels)
- \( \text{BSA} \) = Body surface area
- \( \text{RCA}' \) = Corrected residual cortical activity

Basic Calculations
Global Renal Function Calculations

\[
\ln \text{Creatinine} = 1.22 - 0.55 \times \ln \text{MADRE}
\]

\[
\text{Creatinine} = \frac{e^{1.22}}{(\text{MADRE})^{0.55}}
\]

\[
\text{Creatinine} \approx \frac{3}{\sqrt{\text{MADRE}}}
\]

\(\ln\): natural logarithm
MAG3 Accumulation and Discharge Rate Equivalent

\[
\ln \text{Creatinine} = 1.22 - 0.55 \times \ln \text{MADRE}
\]

ln: natural logarithm
Results: Prediction of Creatinine levels by the Formula GRF
Comparison with real Creatinine values
NORMAL STUDIES

what is a normal study?
Findings: L and R kidneys orthotopic, normal size, normal flow and function, normal cortical activity, normal drainage

Right kidney thinner with split renal function 56%/44% L/R

Adult with renal colic
NORMAL STUDIES

A variation of Normal
Findings: L and R kidneys orthotopic, normal size, subnormal flow and function, slightly delayed cortical activity, Left kidney has a dilated Extra-Renal Pelvis which retains the activity, although the cortex empties. Adult asymptomatic with pelviectasis by CT and normal renal function.
CLINICAL EXPERIENCE

Many misconceptions were clarified
New horizons were discovered
NORMAL STUDIES

Misconceptions:
You cannot study the newborn
You need to catheterize the bladder

Facts
You can study the newborn
you don’t need to catheterize the bladder
Evaluate Pelviectasis found by Ultrasound
Typical ${\text{MAG}}_3$-$F_0$ study in a Newborn; No bladder catheter

Kidneys empty. No Obstruction; Slight Immaturity; Study Normal for Age

The infant **urinated** twice during the study = No need for catheter
Evaluate Pelviectasis found by Ultrasound
Typical MAG3-F0 study in a Newborn; No bladder catheter

What happens if the infant does not empty the Bladder?

Kidneys empty. No Obstruction; Slight Immaturity; Study Normal for Age
A 7 yo boy without bladder catheter has a MAG3-F0 study

Indication: Evaluate effects of urinary tract infection.
MAG₃-F₀ in a 10 yo CHILD; Mature Normal Kidneys

Slight discrepancy in size and function (effect of old infection on the right)
Evaluate Renal Colic. Is there obstruction?
Indication: Renal Colic in an adult

Normal MAG₃ - F₀ in an ADULT

Tc-99m-MAG₃-F₀ Diuretic Dynamic Renal Study

flow (3 sec images)

function / drainage (2 min images)

renograms of the kidneys

Left kidney

53%

Right kidney

47%

split renal function

1-2 min image SRF

renograms of the cortices

1-2 min image SRF
Misunderstanding

Ye have heard that it was said by them of old time:
You cannot do tomography with MAG₃

But we say unto you
MAG₃ can do tomography within 4 minutes

And we can use SPECT/CT to localize and identify lesions
NORMAL MAG$_3$-F$_0$ SPECT (tomogram) 
tomograms axial/coronal/sagittal

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35yo female with history of pyelonephritis
Evaluate Obstruction

INDICATIONS

1) To differentiate between Dilatation without Obstruction and Partial Obstruction
2) To confirm Complete Obstruction

PRINCIPLE

Diuresis (completely) washes out the activity from collecting system when there is no obstruction but fails to do so in obstructive uropathy
DIURECTIC RENOGRAPHY: to make the diagnosis of Kidney Obstruction

**WHITAKER TEST**

At 10 ml/min infusion a renal pelvis pressure >10 cm water from the pressure in the bladder defines obstruction

Problem 1: It is an invasive method

Problem 2: Many kidneys cannot produce 10 ml/min urine (hypofunctioning) = FP
Misconceptions
For Diuretic Renography you need to inject the diuretic either 20-30 min after MAG3 (old O’Reily=\(F_{+20/30}\)) or 15 min before MAG3 (new O’Reily =\(F_{-15}\)).

Fact
You can inject MAG\(_3\) and Lasix Simultaneously (\(F_0\)).
DIURETIC RENOGRAPHY

TIMING OF DIURETIC INJECTION

\( F_{+20} \) : 20-30 min POST MAG\(_3\) (old O’Reily)
(40-50 min study time)

\( F_{-15} \) : 15 min PRE MAG\(_3\) ……(new O’Reily)
(35-40 min study time)

\( F_0 \) : SIMULTANEOUSLY with MAG\(_3\) (UM)
(22 min study time)
COMPARATIVE STUDY OF THE TIMING OF DIURETIC INJECTION
UM/JMH PRESENTED SNM AM 2000
COMPARATIVE STUDY OF THE TIMING OF DIURETIC INJECTION
UM/JMH PRESENTED SNM AM 2000

MAG$_3$ F$+20$  

MAG$_3$ F$-15$  

HIP F$_0$
DIURETIC RENOGRAPHY with the THREE METHODS:

Results: Equivalent

Radiation Exposure: Higher with $F_{+20}$

Duration of the Examination

- The Old O'Reily $F_{+20}$: 40+ min
- The New O'Reily $F_{-15}$: 40 min
- The $F_0$: 22 min
ZERO TIME INJECTION DIURETIC RENOGRAPHY (F₀):

- It is at least as **Accurate** as F+20/30 and F-15
- Better Tolerated (Shorter – One Injection)
- Fewer interruptions in adults for voiding
- Cost **Effective** as it is Concluded in 25 min
- Reduces the Radiation Exposure of the Patient
- It Allows The Evaluation of the Parenchyma
These two studies prove the opportunity to study the cortex
On the left the study is F+20
On the right it is F0

Which one can evaluate the parenchyma?
**NORMAL MAG3**

Diuretic given at F+20
Cortex full of urine
cannot be studied effectively

Diuretic F+20

---

**NORMAL MAG3**

Diuretic given at F0
Cortex is empty and
can be studied effectively

Diuretic F0
RENAL SCINTIGRAPHY AT UM/JMMC: (MAG₃-F₀)
Method applied the last 17 years:

This protocol was originally applied in the evaluation of drainage

Soon it was realized that it allowed the evaluation of the parenchyma

Then it was applied in all parenchymal indications (including APN)

It was also utilized for the study of Renovascular Hypertension

It allowed the study of HIV and other Acquired Nephropathies

In patients with renal colic unraveled the Stunned (decompressed) kidney

It was finally successful in the study of complications of renal transplants
NEW HORIZONS

- Obstruction
- Focal Parenchymal Disease
- Diffuse Parenchymal Disease
- RVH
- Renal Colic
- Complications of renal Transplants
OBSTRUCTION

Misconception:
To make the Diagnosis of Obstruction
you need to Study the Collecting System of the Kidney

New Horizons:
To make the Diagnosis of Obstruction
you better study the behavior of the Renal Cortex:

If the cortex empties, there is no obstruction!
(even when the drainage system is dilated
and it does not empty appropriately)

Study presented SNM 2003
L kidney: Collecting System Retention and Cortical Retention
DIAGNOSIS OF OBSTRUCTION: THE CORTEX

If the Cortex (parenchyma) empties, there is not obstruction.

S/P ENDOPYELOPLASTY

ASYMPTOMATIC, 60yo with EXTRARENAL PELVIS

R. COLIC: R. OBSTRUCTION, L. NO OBSTRUCTION + PELVICALIECTASIS
An adult had endopyeloplasty 6 months ago to relieve obstruction. He is now evaluated for the results of the operation.
EXTRARENAL PELVIS s/p ENDOPYELOPLASTY without OBSTRUCTION

There is retention within an enlarged remaining pelvis but the cortex empties.
Asymptomatic 55 yo man with incidental finding of “hydronephrosis” on CT
EXTRARENAL PELVIS without OBSTRUCTION

There is retention within a large extra-renal pelvis

but the cortex empties
A patient with a history of bilateral nephrolithiasis is studied because of a recent Right Colic.
IF THE CORTEX EMPTIES, THERE IS NO OBSTRUCTION

In the presence of a dilated, abnormal collecting system

- The Non-Obstructed Cortex Empties
- The Obstructed Cortex does not empty

Left: Non-obstructed  Right: Obstructed

Left: Non-obstructed  Right: Obstructed
A 12 year old child is evaluated because the U/S suggested bilateral “hydronephrosis”
MAG$_3$ - F$_0$ in Pelviectasis without Obstruction

There is retention within dilated renal pelvices bilaterally but the cortices empty.
Evaluate “hydronephrosis” found by ultrasound in a newborn
EXTRARENAL PELVIS without OBSTRUCTION

Newborn

17 month old

10/30/96

4/9/98

1. Image # 1  2. Image # 63  3. Image # 67  4. Image # 71


12. POST-VOID 1

12. POST-VOID 1

RENAL DELAYS, Ste

COUNCIL FOR REGIONAL UROLOGY (CRU) 1997
THE VALUE OF MAG₃ -F₀ DIURETIC RENOGRAPHY IN PREDICTING THE NEED FOR SURGERY IN THE NEONATE WITH URETEROPELVIC JUNCTION OBSTRUCTION


Abstract: SNM 2000

RENAL SCINTIGRAPHY IN INFANTS AND CHILDREN

GEORGE N. SFAKIANAKIS AND EFROSYNI SFAKIANAKI

UROLOGY 57: 1167–1177, 2001
CONGENITAL RENAL OBSTRUCTION
THE NEED FOR SURGICAL CORRECTION

In the neonate a rising renogram mandates surgical correction

A downsloping renogram promises spontaneous normalization
PELVIECTASIS: MILD OBSTRUCTION

A down-sloping MAG₃-F₀ renography in the neonate predicts Spontaneous Compensation
PELVIECTASIS: SEVERE OBSTRUCTION

An Up-sloping MAG$_3$-F$_0$ renography in the neonate predicts

The need of Surgical Correction
A Horizontal Renogram requires follow up studies
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<th>Condition</th>
<th>Description</th>
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<tr>
<td>Dysplasias</td>
<td>Renal tissue abnormality</td>
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<td>Agenesis</td>
<td>Renal system absence</td>
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<tr>
<td>Hypoplasia</td>
<td>Renal tissue underdevelopment</td>
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<td>Polycystic-Dominant</td>
<td>Multiple cysts</td>
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<td>Multiple cysts</td>
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<td>UPJ-Obstruction</td>
<td>Upper urinary tract obstruction</td>
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<td>UVJ-Obstruction</td>
<td>Lower urinary tract obstruction</td>
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CONGENITAL RENAL DISORDERS

Nuclear Medicine in Congenital Urinary Tract Anomalies

G. N. Sfakianakis

MOST COMMON INDICATIONS FOR RENAL SCINTIGRAPHY

NEONATE

- Congenital Renal Insufficiency/Failure
- Perinatal Complications
- Work Up of Sonographic Findings
- Masses in the Abdomen
- Search for and Evaluation of Congenital UT Anomalies

Diagnosis, Prognosis, Follow Up
A Newborn child with no urination for 24 hr
CONGENITAL RENAL INSUFFICIENCY/FAILURE

Bilateral Dysplasias

L kidney: No function with lucences
R kidney: Barely functioning

- Bilateral Multicystic Dysplasias, left worse than right
- No functioning (left) or barely functioning (right) renal parenchyma
- No Intervention indicated, no recovery expected
A Newborn child with no urination for 24 hr
US showed bilateral hydronephrosis
CONGENITAL RENAL INSUFFICIENCY/FAILURE

Posterior Urethral Valves

Presence of functioning renal parenchyma

Bilateral Hydronephrosis = Obstruction:
Intervention indicated, some recovery expected
A newborn with congenital renal insufficiency
U/S: Bilateral Hydronephrosis
CONGENITAL RENAL INSUFFICIENCY/FAILURE

Bilateral obstruction (UPJ)   
Worse on the Left

Early Correction of UPJO  
(the first week of life)  
may Prevent Loss of Function  
and may Promote  
Recovery of Function

There is substantial  
 improvement of the left kidney

The right remains unchanged
MOST COMMON INDICATIONS FOR RENAL SCINTIGRAPHY

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Diagnosis, Prognosis, Follow Up
A newborn with Ischemia during birth from a diabetic mother, is in Renal Failure
U/S normal
**MAG₃ - F₀ in Acute Tubular Necrosis**

Kidneys orthotopic, with preservation of flow and accumulation. No drainage problem. Cortical retention of activity.

No Intervention indicated, full recovery expected.
PERINATAL RENAL INSUFFICIENCY/FAILURE

Acute Tubular Necrosis

- Ischemia during birth from a diabetic mother
- No Intervention indicated, full recovery expected
Neonates with hypertension from renal ischemia due to thrombus in the umbilical catheter shall not be treated with ACE-Inhibitors
A newborn with umbilical artery catheterization for therapy developed hypertension. A baseline and an ACE-Inhibition renal study was performed.
Left Kidney not visualized = infarcted
Right Kidney normal at BSL, but with no excretion after ACE-Inhibition
Right Kidney normal renogram at BSL, but with cortical retention after ACE-Inhibition
MOST COMMON INDICATIONS FOR RENAL SCINTIGRAPHY

NEONATE

Congenital Renal Insufficiency/Failure
Perinatal Complications
Work Up Of Sonographic Findings
Masses in the Abdomen
Search for and Evaluation of Congenital UT Anomalies

Diagnosis, Prognosis, Follow Up
The children in the following studies had abnormal U/S studies as defined in each case individually.
PELVIC ECTOPIC NORMAL RIGHT KIDNEY
Less active than the right because it is deeper (more attenuation)

U/S: Non-visualization of the right kidney
NORMAL HORSE-SHOE KIDNEY

Newborn 2do with questionable U/S

Horse-shoe kidney with Normal Function and Drainage

Immaturity with Increased Residual Cortical Activity
HYPOPLASIA with contralateral compensatory HYPERTROPHY

5 yo child with an U/S indicating a small left kidney

Hypoplastic, but normally functioning left kidney and compensatory Hypertrophy of the R

2 min

20 min
AGENESIS

U/S: Non-visualization of the left kidney
Two congenital malformations deal with cysts

a) The Multicystic Kidney
   Unilateral/Non-functioning/US detectable

b) Polycystic Kidney Disease
   Bilateral/Functioning/US undetectable
LEFT MULTICYSTIC DYSPLASTIC KIDNEY  
RIGHT NORMAL  

U/S: Cysts in the left kidney  

Non-Functioning left kidney with background defect =  
Multicystic dysplastic kidney
Differentiate a MULTICYSTIC kidney from AGENESIS

No BKG Defect: AGENESIS

BKG Defect: MULTICYSTIC

A correct U/S study shows Cysts in Multicystic kidney
Duplicated Left Kidney with Multicystic Dysplastic Upper Moiety
POLYCYSTIC KIDNEY DISEASE

Autosomal Recessive

In Children
Asymptomatic
Difficult to diagnose

Autosomal Dominant

In Adults
May have symptoms
Cysts on US/CT
POLYCYSTIC KIDNEY DISEASE
AUTOSOMAL RECESSIVE

Mild Infantile Type

Large Kidneys with good drainage
POLYCYSTIC KIDNEY DISEASE
AUTOSOMAL DOMINANT

Fragmented parenchyma around the cysts / multifocality of the collecting system / satisfactory drainage (unless there are complications=obstructions)
Fragmented parenchyma around the cysts / multifocality of the collecting system / satisfactory drainage (unless there are complications=obstructions)
MAG$_3$ - $F_0$ in Congenital Renal Obstruction

UPJO

UVJO
OBSTRUCTION

Can we prevent the loss?

Neonate

5 year old
The following three patients were sent for MAG3-F0 because they were thought obstructed
Pelviectasis: No Obstruction

This patient had a MAG3 study at an outside lab, which was read as UPJO. The referring physician had asked to use a bladder catheter.

Both kidneys drained adequately: No obstruction
Extravasation / No Obstruction

Continuously increasing background and kidney activity
**Pelviectasis: No Obstruction**

**Infant with an U/S indicating left “hydronephrosis”**

- The kidneys empty: No obstruction
- Pelviectasis of the left kidney
The next two infants are evaluated because the U/S showed Hydronephrosis on the left in the first and on the Right in the second
Left Pelvic Retention + Cortical Retention + No Ureteral Retention = Proximal Obstruction (Uretero-Pelvic Junction, UPJ)
DISTAL (UVJ) OBSTRUCTION

Left Pelvic Retention + Cortical Retention + Ureteral Retention =

Distal Obstruction (Uretero-Vesical Junction, UVJ)
Abnormal U/S of the kidneys
Left hydronephrosis
Duplication with Ectopic Ureter  Ureterocele and Upper Moiety Obstruction
Duplication with Ectopic Ureter  Ureterocele and Upper Moiety Obstruction

New born with prenatal hydronephrosis

Left Lower Moiety: Good early uptake with late emptying: Normal

Left Upper Moiety: Defect at 2 min, which accumulates later: Obstruction
The next two patients are evaluated for obstruction because their ureters were found dilated
NEUROGENIC BLADDER

Abnormal Bladder and Dilated Ureters

Normal drainage
IDIOPATHIC MEGAURETER

Retention within a dilated ureter and pelvis

The cortex empties appropriately

3 months later the ureter empties
VESICO-URETERAL REFLUX

Manometric Nuclear Cystography
Follow up patients with congenital urinary tract anomalies
There is a disparity between the function of the two moieties but the kidney empties appropriately.

Horse-shoe kidney non obstructed at birth and f/u at 6 years of age.
Follow Up Effect of Surgery

Posterior Urethral Valves

<table>
<thead>
<tr>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 min</td>
<td>0-2 min</td>
</tr>
<tr>
<td>8-10</td>
<td>8-10</td>
</tr>
<tr>
<td>16-18</td>
<td>16-18</td>
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Improvement in Function and in Drainage of the left and the right kidney
RENAL SCINTIGRAPHY AT UM/JMMC: (MAG3-F0) Method applied the last 17 years:

One only Protocol: Simple, Easy and Fast (22 min):
- No Bladder Catheterization / Oral Hydration
- One Injection (MAG3 and Diuretic simultaneously = F0)
- The Same Protocol for All Indications (APN) since 1994
- It serves the vast Majority of Cases (not the Exceptions)

Education of Referring and User Physicians
Participation in Clinical/Educational Activities of Clinicians
Research and Publications with Clinicians

Results: 7-15 renal studies per day the last few years