Radionuclide Scans
DMSA, DPTA, MAG3

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Radionuclides in Urology

- Radioactive tracers added to a compound, with a specific interaction with the target organ
- The resulting ionizing radiation is detected and quantified by a gamma camera
- The agent of choice depends on the precise function being evaluated
Radionuclides in Urology

• Radiopharmaceutical
• Data acquisition (Gamma camera and collimator)
• Computer data analysis
• Interpretation of result
Radiopharmaceutical

Pharmaceutical

- DTPA
- DMSA
- MAG3

Radionuclide label

- Technetium – 99
Radionuclides in Urology

Ideal Radiopharmaceutical

1. Easily and cheaply generated
2. Radiochemically pure; concentrate only in organ under investigation
3. Non-toxic
4. Should emit only gamma rays (100–200keV energy)
5. Half-life long enough to complete investigation
6. Half-life short enough to minimize patient radiation risk
Radiopharmaceutical

*Technetium – 99 (\(^{99m}\text{Tc}\))*

- Emission by gamma rays only
- Energy 140 keV
- Half life 6 hrs
- Readily available from generator
Radionuclides in Urology

- Renal perfusion and relative function
- Obstruction (Lasix renal scan)
- Infection (renal morphology scan)
- Pre-surgical quantitation (nephrectomy)
- Renal transplant
- Congenital anomalies, masses (renal morphology scan)
Renal Function

- Blood flow – 20% cardiac output (1.2L/min)
- Filtration – 20% renal plasma flow filtered by glomeruli (120 ml/min)
- Tubular secretion
- Tubular reabsorption
## Renal Radiotracers

### Excretion mechanism

<table>
<thead>
<tr>
<th>Radiotracer</th>
<th>GF</th>
<th>TS</th>
<th>TF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tc-99m DTPA</td>
<td>&gt;95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tc-99m MAG3</td>
<td>&lt;5%</td>
<td>95%</td>
<td></td>
</tr>
<tr>
<td>Tc-99m DMSA</td>
<td>some</td>
<td></td>
<td>60%</td>
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# Choosing Renal Radiotracers

<table>
<thead>
<tr>
<th>Clinical question</th>
<th>Agent</th>
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<tbody>
<tr>
<td>Perfusion</td>
<td>MAG3, DTPA</td>
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<tr>
<td>Morphology</td>
<td>DMSA</td>
</tr>
<tr>
<td>Obstruction</td>
<td>MAG3, DTPA</td>
</tr>
<tr>
<td>Relative function</td>
<td>All</td>
</tr>
<tr>
<td>GFR</td>
<td>DTPA</td>
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Renogram

• Renal scan – graphic record of renal excretion of radioactive tracer that has been injected
• DTPA
• MAG3
Renogram

Radiopharmaceutical

- DTPA
  - Commonly used
  - Cleared solely by glomerular filtration
  - Kidney uptake low, blood background high
  - Background subtraction more difficult esp children or pt with poor renal fx
MAG3 Renogram

- Small proportion undergoes glomerular filtration
- Clearance is predominantly by tubular secretion
- Greater kidney uptake less blood background
- The 30-minute excretion of MAG3 is 70%, and by 3 hours 90%
- Adequate tool for the assessment of urinary uptake, transit, excretion, and split renal function.

Preferred radiopharmaceutical
Renogram

Indication

• Assessment of whole or relative kidney
• Assessment of kidney drainage in obstructive uropathy
• Assessment of congenital renal abnormalities
• Identification of vesicoureteric reflux
Renogram

Preparation
• Hydration
• Void before injection
• Void at the end of study

Data acquisition
• Seated with back to gamma camera
• Supine
• Dynamic series images 1 frame /20s for 30-40 minutes
• **Advantages**
  • Provides sensitive indices of tubular function and urinary excretion
  • Virtually no contraindications
  • Non-nephrotoxic
  • No significant risk of allergic reactions
  • Serial examinations possible (often required)
  • Side effects are rare (unless frusemide or captopril is used)

• **Drawbacks**
  – Exposes patient to radiation
  – Length of study (can take up to 1 hour)
  – Prone to artifactual errors
  – Limited anatomical information
  – Equivocal results require a repeat procedure
  – Inaccurate outlining of ROIs can affect curve dynamics
Diuresis Renogram

• Maximal diuretic response within 5–10 minutes
• Rationale: increase the sensitivity of the dynamic renal study by increasing urine flow rates to stress the system, such that minor degrees of obstruction are unmarked
• Make sure no contraindication
• Various protocol: F+20, F-15, F+0
Fig. 22.1 (a–d) The renogram curves that might be seen following furosemide given 20 min after the radiopharmaceutical.

Fig. 22.2 (a, b) The renogram curves that might be seen when furosemide was given 15 min before the radiopharmaceutical.
Factors Influencing MAG3 Renogram

- Renal function
- Hydration
- Collecting system capacity
- Collecting system compliance
- Bladder effects
- Ureteric dilatation or obstruction
Renogram: Interpretation

- Depends on uptake from blood into kidney and elimination from kidney into bladder
- Three phases
- Renogram curve patterns: to assess the shape of the curve and examine the sequential analog images
- Split renal function
Renogram : Phases

1. Vascular phase
   • First few seconds after injection
   • Most of this part extracted, remain in blood within kidney

2. Uptake phase
   • 1 min onwards

3. Elimination phase
   • Anytime after 3 min
O`reilly Curve

• Type I—normal response
• Type II—obstructive response (high-pressure system)
  – no response to frusemide
  – Inconclusive if GFR <15mL/min
• Type IIIa—dilated but not obstructed (low pressure/ hypotonic system)
  – stasis rather than obstruction
  – prompt elimination following frusemide injection
• Type IIIb—equivocal response
  – languid response to diuretic
  – Repeat study with F-15
• Type IV—delayed compensation (Homsy’s sign)
  – “double peak” response to diuretic
  – F-15 diuresis often reveal obstructed pattern
O`reilly Curve
Diuresis Renogram

Principle

- Hydronephrosis: tracer pooling in dilated renal pelvis
- Lasix increases urine flow
- If obstructed – will not wash out
- If dilated non obstructed – will wash out
Diuresis Renogram

- Non obstructed
• Pre lasix
• Post lasix
Diuresis Renogram

- Obstructed
• Left hydronephrosis
• Left PUJ obstruction
Diuretic Response (Washout T\(_{1/2}\))

- Time require for 50% tracer to leave the dilated kidney
- Normal: < 10 min
- Obstructed: > 20 min
- Indeterminate: 10 – 20 min
Diuretic Response (Washout $T_{1/2}$)

Factors influencing $T_{1/2}$

- Hydration
- Volume of dilated pelvis
- Bladder catheterization
- Dose of lasix
- Renal function
Pitfalls

*False positive for obstruction*

- Distended bladder
- Gross hydronephrosis
- Poor function
- Dehydration

*False negative*

- Low grade obstruction
- Poor function
Diuresis Renogram F-15

- Lasix injected 15 min before radiopharmaceutical
- Rationale: kidney in maximal diuresis, maximal stree
- Some equivocal will become positive, some negative
DMSA
(99mTc-dimercaptosuccinicacid)

- High affinity for the renal cortex
- The preferred radiopharmaceutical for static parenchymal imaging
- Provides the most accurate assessment of relative renal function
- Minimal GFR clearance
- Extracted by the cells of the proximal convoluted tubules allowing slow concentration of radioactivity in the renal cortex
- After 3 hours, about 50% of the injected tracer is concentrated in the kidneys, remaining there for up to 24 hours.
DMSA

**Indications**

- Assessment of relative renal function
- Detection of renal scarring with a sensitivity of 96% and specificity of 98%
- Investigation of renal anomalies
- Examination of space occupying renal lesions
DMSA : Interpretation

• Normal kidney : homogeneous parenchymal distribution

• Acute PN
  - single or multiple “cold” defects
  - renal contour not distorted
  - diffuse decreased uptake
  - diffusely enlarged kidney or focal bulging

• Chronic PN
  - volume loss, cortical thinning
  - defects with sharp edges
DMSA : Interpretation

Congenital anomalies

• Agenesis
• Ectopy
• Fusion (horseshoe)
• Polycystic kidney
• Multicystic dysplastic kidney
• Horseshoe kidney
DMSA

• Advantages
  ➢ Provides excellent cortical images
  ➢ Accurate split renal function estimation
  ➢ Non-nephrotoxic
  ➢ No significant complications
  ➢ Allergic reactions are exceptionally rare

• Drawbacks
  ➢ Involves radiation
  ➢ Does not allow dynamic assessment of renal excretion
Radioisotope GFR study

DTPA (99mTc diethylene-triamine-pentaacetic acid)

*Ideal radioactive tracer*

- Cleared solely, completely, and unmodified by glomerular filtration
- Should not undergo tubular secretion or resorption
- Non-toxic, stable, and not bound to serum proteins
- Readily measured in blood or urine
- Should have a constant clearance irrespective of plasma concentration
**DTPA : GFR**

**Advantages**
- Accurate
- No need for 24-hour urine collections
- Mandatory in clinical trials investigating progressive renal failure

**Drawbacks**
- Invasive—repeated blood samples
- Involves a small amount of radiation
- Lengthy procedure
- Artifacts can be caused by inaccurate recording of times, tracer extravasation at injection site, significant edema, or ascites
Thank You