Radionuclide Studies in Renovascular Hypertension (RVH) in Paediatric Population

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## Renovascular Hypertension
### Imaging Studies

<table>
<thead>
<tr>
<th>Method</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| Doppler ultrasound | • Reasonable cost  
                         • Wide availability  
                         • No ionizing radiation | • Operator-dependent  
                               • Many non-diagnostic studies |
| Angio MRI      | • Useful to separate responders from non-responders  
                         • No ionizing radiation | • Low resolution (small vessels)  
                               • Motion artifacts, stents |
| Captopril MRI | • No nephrotoxic contrast media  
                         • Patient with renal failure  
                         • No ionizing radiation | • High cost  
                                • Limited availability  
                                • Low PPV |
## Renovascular Hypertension Imaging Studies

<table>
<thead>
<tr>
<th>Method</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| **Angio CT**            | - High spatial resolution  
- Shows calcium content  
- No stent artifacts  
- Measures cortical thickness and renal size | - Nephrotoxic contrast media  
- High dosimetry  
- Poor visualization small vessels |
| **Captopril Renography**| - Reasonable cost  
- Identifies responders  
- High NPV | - Low resolution (small vessels)  
- Motion artifacts, stents |
| **Renal Angiography**   | - “Gold standard” for renal artery stenosis  
- Less contrast volume if digital subtraction is used | - Nephrotoxic contrast media  
- High dosimetry  
- Interobserver variability |

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Renovascular Hypertension
Pathophysiology

Renal artery stenosis

Reduced perfusion of affected kidney

Attempting to preserve / increase renal blood pressure

Renin-angiotensin system is activated
Releasing:
- angiotensin II
  vasoconstriction
- aldosterone
  plasma expansion
Renovascular Hypertension
Pathophysiology

PHARMACOLOGIC BLOCKADE
of activated renin-angiotensin system

FUNCTIONAL DETERIORATION
of stenotic kidney

REVERSIBILITY
• greater in initial phase
• predicts a good response to revascularization

• Renogram: MORPHO-FUNCTIONAL
• Information on reversibility of arterial lesion

DETECTED THROUGH FUNCTIONAL STUDIES

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Renovascular Hypertension
Chronic Phase

PHARMACOLOGIC BLOCKADE
less effective

“FIXED” HIPERTENSION

NON-REVERSIBLE HIPERTENSION
AFTER REVASCULARIZATION
(DILATION OF STENOTIC ARTERY)

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Renal Angiography

- “Gold standard” for diagnosis of RVH.
- Detects anatomic changes in renal arteries.
- Does not inform about:
  - functional changes
  - reversibility of the lesion

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Captopril Renography

- Well standardized technique
- Neds comparison of:
  - basal vs.
  - post-captopril renography

en caso de HTA con estenosis reversible de la arteria renal
• disminución del filtrado glomerular del riñón afecto y
• aumento del tiempo de tránsito renal del trazador

CAPTOPRIL:
- disminuyendo la VC de la arteriola eferente post-glomerular
- evita la conversión de angiotensina I a angiotensina II

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Captopril Renography
Patient Preparation

- withdraw ACE inhibitors
  - 5-7 days before the study

- temporarily suspend diuretics
- temporarily suspend calcium channel blockers

- The technique is applicable to patients
  - with one kidney
  - with renal transplantation

But a captopril dose adjustment is needed
Captopril Renography
Technique

PREPARATION

• Hydration

• Micturition

• 0.25 mg /kg furosemide intravenous at minutes 0 (to avoid ectasia in excretory pathways)

• Withdraw ACE inhibitors
• Withdraw, if possible, diuretics and calcium blockers
**CAPTOPRIL**

- Administration of captopril orally (or intravenously) 60 minutes before the study

- Typical dose:
  - 50 mg adults - 25 mg in single kidney
  - dose weight adjusted

- BP and HR monitoring: at least 2 determinations
  - Before administration of captopril
  - before the start of the renogram
Captopril Renography Technique

LIMITATIONS
• Low or very low function of affected kidney
• Transient decrease in glomerular filtration rate secondary to
  ✓ Intravenous injection of contrast (CT angiography)
  ✓ On the preceding 2 weeks
  ✓ Both ionic and non-ionic contrast

RADIOPHARMACEUTICALS AND TECHNIQUE
• Adults and children
  ✓ DTPA or MAG3 renogram
• Infants and young children and in cases of suspected pathology of a polar artery
  ✓ DMSA renal scan

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$^{99m}\text{Tc-DTPA}$

$^{99m}\text{Tc-DMSA}$

$^{99m}\text{Tc-MAG}_3$
Captopril Renography
Interpretation: Basal vs. Captopril comparison

Positive findings:

RENOCGRAM
\[ {^{99m}}\text{Tc-DTPA} \]
\[ {^{99m}}\text{Tc-MAG}_3 \]
- ↓ function
- ↑ transit time
- cortical tracer retention

CORTICAL SCINTIGRAPHY
\[ {^{99m}}\text{Tc-DMSA} \]
- ↓ function
  - diffuse
  - focal

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Segmental renal artery stenosis diagnosed with captopril renography in a child

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BASAL RENOGRAM
- RK
- LK
  ✓ preserved function and excretion bilaterally post-captopril

CAPTOPRIL RENOGRAM
- RK
- LK: focal area with prolonged transit time

Segmental renal artery stenosis diagnosed with captopril renography in a child

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Digital subtraction angiography:

- Multiple small aneurysms associated with irregularities of medial and inferior polar arteries.
- Focal stenosis >70% subsegmental artery.

Segmental renal artery stenosis diagnosed with captopril renography in a child

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Left renal artery stenosis

Hypotensive Response to Captopril: A Potential Pitfall of Scintigraphic Assessment for Renal Artery Stenosis

Table 1 Clinical data of 20 hypertensive children evaluated with captopril renal scintigraphy (CRS) (RVH renovascular hypertension, NA not applicable, LK left kidney, RK right kidney, BP blood pressure, HP high probability of RVH, LP low probability of RVH)

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Side(^a)</th>
<th>CRS</th>
<th>Treatment</th>
<th>Follow-up</th>
<th>Final diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 years</td>
<td>M</td>
<td>Takayasu arteritis</td>
<td>LK</td>
<td>HP LK</td>
<td>Surgery</td>
<td>Normal BP with drugs(^b)</td>
<td>RVH</td>
</tr>
<tr>
<td>6 years</td>
<td>F</td>
<td>Aortic coarctation</td>
<td>Bilateral</td>
<td>HP Bilateral</td>
<td>Surgery</td>
<td>Normal BP with drugs(^b)</td>
<td>RVH</td>
</tr>
<tr>
<td>3 months</td>
<td>F</td>
<td>Unclassified arteritis</td>
<td>Bilateral</td>
<td>HP Bilateral</td>
<td>Surgery</td>
<td>Normal BP</td>
<td>RVH</td>
</tr>
<tr>
<td>6 years</td>
<td>M</td>
<td>Post-traumatic thrombus</td>
<td>LK</td>
<td>HP LK</td>
<td>Medical</td>
<td>Normal BP with drugs(^b)</td>
<td>RVH</td>
</tr>
<tr>
<td>14 years</td>
<td>M</td>
<td>Takayasu arteritis</td>
<td>Bilateral</td>
<td>HP LK</td>
<td>Surgical</td>
<td>Normal BP</td>
<td>RVH</td>
</tr>
<tr>
<td>9 years</td>
<td>M</td>
<td>Fibromuscular dysplasia</td>
<td>Bilateral</td>
<td>HP LK</td>
<td>Surgery</td>
<td>Normal BP with drugs(^b)</td>
<td>RVH</td>
</tr>
<tr>
<td>14 years</td>
<td>M</td>
<td>Fibromuscular dysplasia</td>
<td>RK</td>
<td>Non-diagnostic</td>
<td>Surgery</td>
<td>Normal BP</td>
<td>RVH</td>
</tr>
<tr>
<td>25 days</td>
<td>M</td>
<td>Reflux nephropathy LK</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Surgery(c)</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>15 years</td>
<td>M</td>
<td>Transient hypertension</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>5 years</td>
<td>F</td>
<td>Acute tubular necrosis</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>2 months</td>
<td>M</td>
<td>Transient hypertension, bronchopulmonary dysplasia</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>12 days</td>
<td>F</td>
<td>Pulmonary hypertension, sepsis</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>15 years</td>
<td>M</td>
<td>Chronic renal failure</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>11 years</td>
<td>F</td>
<td>Glomerulonephritis</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>8 years</td>
<td>M</td>
<td>Intramedullary tumor</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>4 months</td>
<td>M</td>
<td>Transient hypertension</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>2 months</td>
<td>M</td>
<td>Nephrocalcinosis</td>
<td>NA</td>
<td>LP Bilateral</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>2 months</td>
<td>M</td>
<td>Freeman Sheldon syndrome, multiple congenital anomalies</td>
<td>NA</td>
<td>HP LK</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>4 years</td>
<td>M</td>
<td>Hypoplasia LK</td>
<td>NA</td>
<td>Non-diagnostic</td>
<td>Medical</td>
<td>Normal BP</td>
<td>Non RVH</td>
</tr>
<tr>
<td>9 years</td>
<td>F</td>
<td>Hypoplasia LK, chronic renal failure</td>
<td>NA</td>
<td>Non-diagnostic</td>
<td>Medical</td>
<td>Normal BP with drugs</td>
<td>Non RVH</td>
</tr>
</tbody>
</table>

\(^a\) According to angiography  
\(^b\) With fewer antihypertensives or lower doses of the same medications  
\(^c\) Left kidney nephrectomy due to reflux nephropathy

Captopril scintigraphy in the study of arterial hypertension in pediatrics

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Renal cortical scintigraphy with $^{99m}$Tc-DMSA
- Focal reduced uptake
- Polar artery stenosis

Hypertension in paediatrics: can pre- and post-captopril technetium-99m dimercaptosuccinie acid renal scans exclude renovascular disease?

### ANGIOGRAPHY

<table>
<thead>
<tr>
<th>SENSITIVITY</th>
<th>64%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFICITY</td>
<td>44%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DMSA (basal)</th>
<th>normal</th>
<th>abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>normal</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>abnormal</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

DRF<45% or focal defect

Hypertension in paediatrics: can pre- and post-captopril technetium-99m dimercaptosuccinie acid renal scans exclude renovascular disease?


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**ANGIOGRAPHY**

<table>
<thead>
<tr>
<th>SENSITIVITY</th>
<th>91%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFICITY</td>
<td>50%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>normal</th>
<th>abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMSA (captopril) normal</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>DMSA (captopril) abnormal</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

Hypertension in paediatrics: can pre- and post-captopril technetium-99m dimercaptosuccinie acid renal scans exclude renovascular disease?

RENOGRAM: LK functional cancellation

ANGIOGRAPHY: Left renal artery stenosis

Radionuclide Investigations of the Urinary Tract in the Era of Multimodality Imaging*
CAPTOPRIL RENOGRAPHY
- Chronic renal failure
- Right $K = 10\%$

ANGIOGRAPHY
- RA stenosis

Radionuclide Investigations of the Urinary Tract in the Era of Multimodality Imaging

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basal captopril

Radionuclide Investigations of the Urinary Tract in the Era of Multimodality Imaging*

http://humanhealth.iaea.org
basal captopril

RENAL TRANSPLANT
- max 25 mg captopril
- captopril:
  - ↓ function
  - ↑ transit time
  - ↓ excretion

Radionuclide Investigations of the Urinary Tract in the Era of Multimodality Imaging*

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Renovascular disease

Radionuclide Renography

- basal
- captopril

\(^{99}\text{Tc}\)-DTPA

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21/03/01

DTPA

PES = 67. KG
ALT = 160 CM
SC. = 1.7 MSQ
INJ = 579 KC
PD = 6.4 CM
PE = 6.4 CM

FGR = 110
ML/MIN/M2
DFGR = 81
EFGR = 29
ML/MIN
%D = 74.%
%E = 26.%

DTMX = 120 SEC
ETMX = 30 SEC

Basal

MINUTES

COUNTS/SEC
Post revascularization
Captopril Renography
Conclusion

Captopril renography is a morpho-functional technique involving low irradiation which gives information about renovascular lesions as well as an estimation of potential lesion reversibility, predicting treatment response.