«Revascularization strategies in children with renovascular hypertension? »

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CHU Nantes

JFCPC 2015
<table>
<thead>
<tr>
<th>Affiliation/Financial Relationship</th>
<th>Company</th>
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Hypertension in children

- Hypertension in children:
- Definition:
  - At least 3 systolic or diastolic values above 97.5\textsuperscript{em} percentile
- Incidence: 1 to 3\% usually asymptomatic (1)
- Usually secondary (2)
  - Renal and renovascular hypertension: (68 to 80\%)
    - Renal: 30-40\% (glomerulopathies…)
    - Renovascular: 5 to 10\% (3)
    - ...
  - Endocrine causes
  - Vascular causes (aortic coarctation…)
  - Neurologic, metabolic…

Tension artérielle en fonction de la taille:

Garçons de 4 à 18 ans

Date de naissance :

TA : mmHg

Systolique

Diastolique

HTA confirmée

HTA limite

Percentiles mmHg

TAILLE

105 115 125 135 145 155 165 175 185

140 130 120 110 100 90 80 70 60 50

160 150 140 130 120 110 100 90 80 70 60 50

180 170 160 150 140 130 120 110 100 90 80 70 60 50

Tension artérielle en fonction de la taille:

Filles de 4 à 18 ans

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Percentiles mmHg

TAILLE

105 115 125 135 145 155 165 175 185

140 130 120 110 100 90 80 70 60 50

160 150 140 130 120 110 100 90 80 70 60 50

180 170 160 150 140 130 120 110 100 90 80 70 60 50

Inserm
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Renovascular hypertension in children
Renovascular hypertension in children
Renovascular hypertension in children
Renovascular hypertension in children

• Definition:
  
  – Heterogeneous group of disorders that is comprised most commonly of intrinsic lesions of the renal arteries, and more rarely is caused by intravascular and extrinsic compressive lesions (1, 2).
  
  – Renovascular lesions may also be associated with involvement of the aorta and its other visceral branches, which is then known as mid-aortic syndrome (MAS) (3).
  
  – The most common causes of RAS are fibromuscular dysplasia (FMD) and Takayasu’s arteritis in children and atherosclerosis in adults (4, 5).

Renovascular hypertension in children

• Causes of RAS:
  
  – Fibromuscular dysplasia
    • Intimal, medial, peri medial
    • Alagille with MAS (1)
  
  – Syndromic causes
    • Recklinghausen (2)
    • Williams et Beuren (3)
  
  – Arteritis
    • Takayatsu
    • Kawasaki
  
  – Compressive lesions
    • Neuroblastomes
    • Néphroblastomes)

We report retrospectively on ten children diagnosed with renovascular hypertension at the University Hospital of Nantes from 2001 to 2012:

The main findings were obtained by fortuitous screening of children aged 2 months to 14 years old.

Causes:
- Neurofibromatosis (n=2)
- Fibromuscular dysplasia (n=8).

## Renovascular hypertension in children

### Table 1: Patient characteristics at the time of presentation

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Discovery</th>
<th>Blood pressure (mmHg)</th>
<th>Etiology</th>
<th>Plasmatic abnormalities</th>
<th>LVH</th>
<th>Retinal abnormalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>M</td>
<td>4.5</td>
<td>Screening</td>
<td>140/110&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NF1</td>
<td>No</td>
<td>No</td>
<td>NA</td>
</tr>
<tr>
<td>II</td>
<td>M</td>
<td>1.5</td>
<td>Screening</td>
<td>125/70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>NF1</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>III</td>
<td>F</td>
<td>2.5</td>
<td>Fortuitous</td>
<td>180/130&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>IV</td>
<td>M</td>
<td>0.1</td>
<td>HHS</td>
<td>180/100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>Hyponatremia and hypokalemia, High RAAS activity</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>V</td>
<td>M</td>
<td>5.7</td>
<td>Fortuitous</td>
<td>160/100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>High RAAS activity</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>VI</td>
<td>M</td>
<td>14.0</td>
<td>Fortuitous</td>
<td>170/100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>High RAAS activity</td>
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<td>NA</td>
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<tr>
<td>VII</td>
<td>F</td>
<td>1.1</td>
<td>Fortuitous</td>
<td>240/120&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>Hypokalemia</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>VIII</td>
<td>M</td>
<td>3.8</td>
<td>Fortuitous</td>
<td>150/100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>High RAAS activity</td>
<td>Yes</td>
<td>NA</td>
</tr>
<tr>
<td>IX</td>
<td>M</td>
<td>13.5</td>
<td>HHS</td>
<td>170/140&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>Hyponatremia and hypokalemia, High RAAS activity</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>X</td>
<td>F</td>
<td>6.0</td>
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<td>150/100&lt;sup&gt;a&lt;/sup&gt;</td>
<td>FMD</td>
<td>No data</td>
<td>Yes</td>
<td>NA</td>
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</table>

<sup>a</sup> Stage 2 hypertension


Renovascular hypertension in children

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<td>Screening</td>
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<td>No</td>
<td>No</td>
<td>NA</td>
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<td>No</td>
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<td>No</td>
<td>No</td>
<td>No</td>
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<td>FMD</td>
<td>High RAAS activity</td>
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<td>NA</td>
</tr>
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<td>F</td>
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<td>FMD</td>
<td>Hypokalemia</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>VIII</td>
<td>M</td>
<td>3.8</td>
<td>Fortuitous</td>
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<td>IX</td>
<td>M</td>
<td>13.5</td>
<td>HHS</td>
<td>170/140 ⁴</td>
<td>FMD</td>
<td>Hyponatremia and hypokalemia High RAAS activity</td>
<td>No</td>
<td>No</td>
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<tr>
<td>X</td>
<td>F</td>
<td>6.0</td>
<td>No data</td>
<td>150/100 ⁴</td>
<td>FMD</td>
<td>No data</td>
<td>Yes</td>
<td>NA</td>
</tr>
</tbody>
</table>

_M_ male, _F_ female, _HHS_ hyponatremic hypertensive syndrome, _NF1_ neurofibromatosis type 1, _FMD_ fibromuscular dysplasia, _RAAS_ renin-angiotensin-aldosterone system, _LVH_ left ventricular hypertrophy, _NA_ not available

⁴ Stage 2 hypertension

### Table 2 Radiological investigations for the initial diagnosis

<table>
<thead>
<tr>
<th>Renal Doppler ultrasound</th>
<th>Nuclear imaging</th>
<th>CT angiography</th>
<th>MR angiography</th>
<th>Arteriography</th>
<th>SAT Doppler</th>
<th>Cerebral MR angiography</th>
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<tbody>
<tr>
<td>I</td>
<td>NA</td>
<td>Right RA stenosis</td>
<td>NA</td>
<td>Stenosis of the right RA trunk</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td></td>
<td>DMSA: N</td>
<td>Moderate right polar RA stenosis</td>
<td>NA</td>
<td>Stenosis of right polar artery</td>
<td>NA</td>
<td>NA</td>
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<tr>
<td>II</td>
<td>N</td>
<td>Mid-aortic syndrome: bilateral RA stenosis and superior mesenteric artery stenosis</td>
<td>NA</td>
<td>Intrarenal aneurysms</td>
<td>N</td>
<td>Right medium cerebral artery stenosis</td>
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<tr>
<td></td>
<td>NA</td>
<td>Major hilar right renal aneurysm</td>
<td>NA</td>
<td>Mid-aortic syndrome: bilateral RA stenosis and superior mesenteric artery stenosis</td>
<td>N</td>
<td>N</td>
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<tr>
<td>III</td>
<td>Severe abdominal aortic stenosis</td>
<td>Mid-aortic syndrome: bilateral RA stenosis, celiac trunk stenosis, and superior mesenteric artery stenosis</td>
<td>NA</td>
<td>Mid-aortic syndrome: bilateral RA stenosis, celiac trunk stenosis, and superior mesenteric artery stenosis</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>IV</td>
<td>N</td>
<td>MAG3: no fixation of the left kidney</td>
<td>NA</td>
<td>Mid-aortic syndrome: abdominal aortic stenosis, aneurysm, and left RA stenosis</td>
<td>NA</td>
<td>N</td>
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<td>V</td>
<td>Bilateral RA stenosis</td>
<td>NA</td>
<td>Mid-aortic syndrome: bilateral RA stenosis</td>
<td>NA</td>
<td>NA</td>
<td>N</td>
</tr>
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<td>VI</td>
<td>Left RA stenosis</td>
<td>NA</td>
<td>Left RA stenosis</td>
<td>Mid-aortic syndrome: bilateral RA stenosis</td>
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<td>N</td>
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<tr>
<td>VII</td>
<td>Left RA stenosis</td>
<td>MAG3: bilateral RA stenosis</td>
<td>Right RA dysplasia</td>
<td>Left RA stenosis</td>
<td>Left RA stenosis</td>
<td>N</td>
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<td>Right RA stenosis (doubt)</td>
<td>MAG3 and DMSA: right hypofixation</td>
<td>Doubt about a right RA stenosis</td>
<td>Left proximal RA stenosis</td>
<td>Left subclavian artery stenosis</td>
<td>N</td>
</tr>
<tr>
<td>VIII</td>
<td>N</td>
<td>MAG3 and DMSA: right hypofixation</td>
<td>Right RA stenosis</td>
<td>Right proximal RA stenosis</td>
<td>Left subclavian artery stenosis</td>
<td>N</td>
</tr>
<tr>
<td>IX</td>
<td>Left RA stenosis</td>
<td>NA</td>
<td>Left RA stenosis</td>
<td>Left polar RA stenosis</td>
<td>Left subclavian artery stenosis</td>
<td>N</td>
</tr>
<tr>
<td>X</td>
<td>N</td>
<td>DMSA: N</td>
<td>Bilateral RA stenosis</td>
<td>RA bilateral stenosis</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Cases in italics indicate an exam that provided a precise diagnosis.

* N normal, NA not available, CT computed tomography, SAT supra-aortic trunk, RA renal artery, DMSA dimercaptosuccinic acid, MR magnetic resonance
Renovascular hypertension in children

• Treatments (1):

• Medical (conservative) therapy

• Interventional therapies:
  – Percutaneous transluminal angiography (PTA)
    • Balloon
    • Stents
    • DES
    • Cutting balloons
    • Drug eluting balloon (DEB)

  – Surgery
    • Removal of the diseased arterial segment and reanastomosis of the renal artery to the aorta
    • Placement of a bypass between the aorta and the renal artery (native or prosthetic graft)
    • Autotransplantation of the affected kidney to a novel site
    • Removal of the artery and kidney via nephrectomy

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age at diagnosis (years)</th>
<th>Medications before invasive treatment</th>
<th>Age at invasive therapy (years)</th>
<th>Invasive therapy</th>
<th>Complications</th>
<th>Age at last follow-up</th>
<th>Maintenance therapy</th>
<th>Invasive therapy result</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>4.5</td>
<td>D</td>
<td>5.5</td>
<td>PTA/RRA</td>
<td>Anurysms not accessible</td>
<td>11</td>
<td>A</td>
<td>Failure</td>
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<tr>
<td></td>
<td></td>
<td>D</td>
<td>6.3</td>
<td>RRA autotransplantation</td>
<td>Partial thrombosis (Fig. 1) and recurrence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D</td>
<td>7</td>
<td>PTA/RRA</td>
<td>New lesions, intra- and extraenral</td>
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<td>D</td>
<td>8</td>
<td>PTA/RRA</td>
<td>Loss of kidney</td>
<td></td>
<td></td>
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<td>ABCFG</td>
<td>2.5</td>
<td>PTA/bilateral</td>
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<td>4.5</td>
<td>AC</td>
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<td>2.5</td>
<td>ABCFG</td>
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<td>PTA</td>
<td>Failure</td>
<td>6.5</td>
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<td>Cure</td>
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<td>Aortic bypass and bilateral autotransplantation</td>
<td>Postsurgery bilateral stenosis recurrence</td>
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<td>A</td>
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<td>PTA/bilateral</td>
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<td>7</td>
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<td>Partial</td>
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<td>VI</td>
<td>14</td>
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<td>–</td>
<td>–</td>
<td>–</td>
<td>17</td>
<td>AD</td>
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<td>VII</td>
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<td>ADG</td>
<td>1.5</td>
<td>PTA/LRA</td>
<td>Partial thrombosis (polar artery)</td>
<td>10</td>
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<td>3.8</td>
<td>A</td>
<td>4</td>
<td>PTA</td>
<td>Recurrence, transitory arterial spasm (polar artery)</td>
<td>15</td>
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<td>PTA cutting balloon</td>
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<td>PTA/stent RRA</td>
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<td>13.8</td>
<td>PTA/LRA active balloon</td>
<td>Recurrence, intrastent thrombosis</td>
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<td>14</td>
<td>PTA/LRA thromboaspiration</td>
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<tr>
<td></td>
<td></td>
<td>E</td>
<td>18</td>
<td>PTA/bilateral</td>
<td>Recurrence</td>
<td></td>
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</tbody>
</table>
Renovascular hypertension in children

• Medical (conservative) therapy (1):

  – Medical intervention can be used as single therapy: when it is mild or unilateral or as a temporizing measure while planning further definitive therapy. Medical therapy will also need to be continued in at least half of children who are treated by interventional means (2-4).

  – Renin-angiotensin-aldosterone blockers are contraindicated until critical main RAS or bilateral RA disease is excluded.

  – Antihypertensive agents: calcium channel blockers, beta blockers, peripheral alpha antagonists, direct vascular smooth-muscle vasodilators, and centrally acting alpha agonists.

  – Diuretics should be used in combination (isolated use may increase renin release).

  – When BP is not adequately controlled, and/or renal vascular disease is in third- and fourth-order branches, ACEi or ARB can be used.

Renovascular hypertension in children

- Interventional therapies: Percutaneous transluminal angioplasty
  - In case of medical therapy failure or if more than 2 medications are required
  - Usually use as first-line interventional treatment in children
  - Surgery should be considered as possible first-line treatment if there is stenosis $>10$ mm or multiple stenosed large vessels, or if MAS is present in association with severe widespread disease, including bilateral RAS (1).

Renovascular hypertension in children

- Interventional therapies: Percutaneous transluminal angioplasty

- Low-profile balloons, such as coronary balloons:
  - Easier to advance within a small artery and through a tight stenosis,
  - Semi-compliant or non compliant

- Balloon diameters:
  - ranging from 1.5 mm to 6 mm
  - Chosen by measuring the adjacent non stenotic, non-aneurysmal portion of the renal artery distal to the post-stenotic dilation or by diameter comparison with the normal contralateral artery.

- In resistant stenoses, cutting balloons may be considered (1, 2)

- If possible, stent should be avoided

Renovascular hypertension in children

- Interventional therapies: Percutaneous transluminal angioplasty
  - Long-term success for PTA in pediatric FMD is less than that reported for adults.
  - The decreased response rate may be a result of smaller vessel diameter, a more pronounced response to growth factors in immature vasculature, and differences in pathology (1).
  - However, children still achieved benefit (cure or improvement) through use of PTA in more than 50% of cases (2).
  - Restenosis risk factors:
    - long lesions,
    - multiple lesions
    - bilateral or intraparenchymal disease
  - PTA may have a role in temporizing hypertension in younger patients prior to later surgery (2, 3).

### Results

<table>
<thead>
<tr>
<th>Nom de l’étude</th>
<th>Nombre de patients</th>
<th>Taux de réussite de l’angioplastie</th>
<th>Stent</th>
<th>Médiane de suivie</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casalini et al. 1995</td>
<td>36</td>
<td>94%</td>
<td>/</td>
<td>2 ans</td>
</tr>
<tr>
<td>Bayazit et al. 2007</td>
<td>16</td>
<td>73%</td>
<td>2 stents</td>
<td>NR</td>
</tr>
<tr>
<td>Shroff et al. 2006</td>
<td>33</td>
<td>55%</td>
<td>15 stents</td>
<td>11,9 ans</td>
</tr>
<tr>
<td>Srinivasan et al. 2010</td>
<td>19</td>
<td>56%</td>
<td>/</td>
<td>10 mois</td>
</tr>
</tbody>
</table>

- In stent restenosis rate: 37%
Renovascular hypertension in children

- Cutting balloon angioplasty

- CBA stenotic lesions resistant to conventional balloon angioplasty, particularly in cases of stenosis related to intimal FMD [2].

- CBA is not a first choice in patients with FMD

- Higher or similar risk of dissection, rupture, and thrombosis?

Renovascular hypertension in children

- Drug eluting stents

- DES: Value of drug-eluting stents is unclear (reduced risk for restenosis when compared to bare metal stents, particularly in smaller vessels)?

- Some trials have not observed major benefits from DES

Renovascular hypertension in children

• Indications for surgery: (1)

  – Failure of conservative therapy with antihypertensive treatment

  – Evidence of end-organ damage

  – Unacceptable side effects/symptoms

  – Previous unsuccessful angioplasty or vascular lesions not amenable to angioplasty.

  – Children with MAS, ostial or proximal lesions, longsegment stenosis, and multiple stenotic areas and aneurysms are best treated surgically (2).

Renovascular hypertension in children

- Surgical procedures:
  - Renal artery reimplantation (onto the aorta, another renal or other splanchnic vessels) is generally the procedure of choice, especially when there is ostial stenosis (1, 2).
  - Aortorenal bypass (autogenous vessels or prosthetic graft)
    - Saphenous vein grafts fell out of favor because of reported cases of aneurysmal deterioration (3)
    - Synthetic prosthetic grafts: risk for infection, technical difficulty with small vessels (1)
    - Currently, the internal iliac artery is preferred for aortorenal bypass (4)
  - Autotransplantation to the iliac vessels (5)
  - Nephrectomy

Traitement médical sans utilisation d’IEC ou d’ARA II.

TA non contrôlée ou nécessitant plus de 2 médicaments.

Angioplastie  
Chirurgie si réalisation aisée  
(ex. néphrectomie)

TA non contrôlée (>95ème percentile)

Angioplastie  
Chirurgie reconstructrice

TA toujours pas contrôlée (>95ème percentile)

Utilisation d’autres traitements, dont l’usage d’IEC ou ARA II avec précaution, si multithérapie nécessaire.

Take home message
Clinical cases

- Maveryck B.
- 3 year old.
- HTA fortuitly discovered
- (150/100 mm Hg)
- Aldosterone an renin ↑
- CT scan, DMSA, Mag 3…
- Bilteral artery stenosis
Clinical cases

• Maveryck B.
• 3 year old.
Clinical cases

- Maveryck B.
- 3 year old.
Clinical cases

- Maveryck B.
- 3 year old.
Clinical cases

- Maveryck B.
- 1 year later:
  - uncontroled HTA.
  - Bitherapy
Clinical cases

- Maveryck B.
- 3 year old.
- Left RAS stenting with DES, Right RAS treated with cutting balloon

Stable. Monotherapy. Residual bilateral RAS 50%
Clinical cases

- Rose M.
- 2 year old
- HTA (fortuitus)
- One aunt with neurofibromatosis
- MAS
- Bilateral RAS
- Uncontrolled despite penta therapy
- Balloon dilatation
- Restenosis
- Surgery 2 months after dilatation
Clinical cases

- Rose M.
- 2 year old
Clinical cases

- Rose M.
- 2 year old
- 2 weeks later

- Stable. monotherapy
Clinical cases

- Louis A.
- 13 year old
- HTA

- Angioplasty left RAS with conventional stent
- 3 months later : restenosis : DEB
Clinical cases

- Louis A.
- 13 year old
- HTA

- Abdominal pain after dual APT interruption
Clinical cases

- Louis A.
- 13 year old
- Abdominal pain after dual APT interruption
Thank you for the attention