In the name of GOD
Imaging protocols in Pediatric Urinary Tract Infections

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My talk will be in 4 parts:

1- Imaging in UTI: yes or no
2- who should be imaged
3- Time of imaging
4- Type of imaging
Urinary tract infections in childhood

Importance:

High incidence
Acute mortality
Chronic hypertension
Malignant hypertension (neurologic complications)
50% underlying anatomical abnormalities
Reflux nephropathy: 3-30% of ESRF
# 0.5 million ESRF 2ndry to RN
Urinary Tract Infections

Incidence:

General population:
- Males: 1%
- Females: 5%

Tx Children: 20-88%
The aim of imaging in UTI is:

To detect conditions that must be corrected to avoid imminent deterioration of kidney function

To prevent recurrent infections affecting long-term kidney damage.

The role of imaging in urinary tract infections

Risk of renal scarring with recurrent UTI

When and which imaging studies to obtain for evaluation of a child with UTI still remain controversial.

The main question fueling the debate is the relevance of VUR in the causal pathway between UTI and renal scarring.

To answer this question, two approaches have evolved: ‘top-down’ and ‘bottom-up’

Curr Opin Pediatr # 2011
Based on the American Academy of Pediatrics (AAP) there was no need for imaging studies in children > 6 months of age for the first uncomplicated UTI, Now is recommended in febrile infants (2-24 m).

However, we face many situations where the parents do not remember any kind of urinary signs or symptoms and the child has multiple renal scars and hypertension and even hypertensive encephalopathy.

Recently we had a 12 yrs old male with severe bilateral hydro, Grade 5 bilateral VUR, Multiple scar came for first time for headache as a result of hypertension.
Imaging protocols in Pediatric UTIs
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Common modalities used for evaluation of UTI

U/S
VCUG

99m Tc-DMSA:
Technetium-99m Dimercaptosuccinic acid

99m Tc-DTPA:
Technetium-99m Diethylenetriamine pentaacetate

99m Tc- MAG3:
Technetium-99m mercaptoacetyltriglycine
## Imaging protocols in Pediatric UTIs

<table>
<thead>
<tr>
<th>Modalities commonly used</th>
<th>Modalities less commonly used</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>Doppler US</td>
</tr>
<tr>
<td>KUB</td>
<td>IVP</td>
</tr>
<tr>
<td>VCUasis (VCUG)</td>
<td>CT scan</td>
</tr>
<tr>
<td>DRNC</td>
<td>MRU</td>
</tr>
<tr>
<td>DMSA</td>
<td>MRA</td>
</tr>
<tr>
<td>DTPA</td>
<td>Angiography</td>
</tr>
<tr>
<td>MAG3</td>
<td></td>
</tr>
</tbody>
</table>
In imaging studies, U/S is a well-known operator-dependent method.

VCUG has lower sensitivity in detecting VUR than DRNC, however, it reveals detailed anatomy of the urinary tract. DRNC has higher sensitivity in detecting VUR but does not show detailed anatomy.

On the other hand VCUG and DRNG both need catheterization and VCUG have a significant radiation burden; many parents are unsatisfied and do not agree for catheterization and of course the physician has radiation concerns for an adolescent girl even when there is recurrent UTIs and evidence of bladder dysfunction.
Imaging in Pediatric Urinary Tract Infections

Medullary nephrocalcinosis

echogenic renal pyramids.
AAP 2012:

**U/S in UTI:**
Yield abnormal result in 15%, 1-2% need action
2-3% false positive result leading to invasive evaluations

Preponderance of Benefits over harms

Parents preference:
US over small risks of missing serious complication

* Remember Operator-dependency
VUR Incidence

0.4-1.8% of unselected children
30-40% of children with UTI
70% of Neonates with UTI
35-51% of siblings of children with VUR
50% of offspring of mothers with VUR
15% of less than 12 years old patients
10% of neonates with hydronephrosis have VUR
Vesicoureteral reflux in children

VUR Incidence:

* 15% of UPJO
* 25% of Neonates with neuropathic bladder at birth
* 50% of Neonates with PUV
Vesicoureteral Reflux

Diagnosis:

Cystography & VCUG:

1- Direct contrast
2- Direct radionuclide
3- Indirect contrast
4- Indirect radionuclide
DRNC- Bilateral VUR
Vesicoureteral reflux in children

High grade reflux with Cross ectopia
Bladder diverticuli
Vesicoureteral reflux, Duplex + Ureterocele
By using DRNC at first study:

We think of Primary VUR

But: In the literature is:

Primary VUR is not a significant risk factor for upper tract deterioration but bladder dysfunction
Conclusions:

One should always be aware that: **bladder dysfunction may cause UTI and renal scarring even without VUR.**

The fact that bladder dysfunction could develop and affect the resolution of VUR has been established by many authors.

Meanwhile, aggressive anti-reflux treatment should not be hesitated if the child fails to stay UTI-free since VUR in combination with UTI are the main causes of renal scarring, especially in patients with bladder dysfunction. Surveillance of bladder dysfunction even after spontaneous or surgical resolution of VUR is warranted.
So we recommend in Diagnosis:

Cystography & VCUG:

First time: Contrast

Follow-up: Radionuclide
Obstructive Uropathy - AUV
VCUG in Child with Voiding Dysfunction

Spinning top deformity
Voiding Dysfunction: Clinical features
Neurogenic bladder (Diverticules)
Neurogenic bladder (Diverticules)
Grade I Vesicoureteric Reflux
Grade II Vesicoureteric Reflux
Grade IV Vesicoureteric Reflux
Grade V Vesicoureteric Reflux
International Reflux Grading classification of vesicoureteral reflux.
Imaging in Pediatric Urinary Tract Infections

DMSA is used to:

1- Show renal involvement during UTI and confirm pyelonephritis

2- Detect renal scar 6 months later
Posterior image of normal kidneys on DSMA scan in a 3 year old with a urinary tract infection.
Normal DMSA Scan
آسیب‌هایی ناشی از عفونت ادراری روی کلیه‌ها
Multiple scars
Renal Scar due to UTI
Imaging in Pediatric Urinary Tract Infections

Renal scar, MDK

[Image of a renal scan with 99mTc (DMSA) showing a kidney with a scar]
DMSA (sensitivity 86%, specificity 91%) performed soon after UTI identifies acute kidney injury.

However, most acute changes resolve over time regardless of whether antibiotic prophylaxis is used.

There appears little benefit in performing a DMSA scan soon after the first UTI.
Hydronephrosis-MAG3
Imaging in Pediatric Urinary Tract Infections

Time-activity curve from 99mTc-MAG3 renal scan showing symmetric prompt excretion of radiotracer, indicating no obstruction.
Motor vehicle collision resulting in extensive left renal laceration with a large perinephric hematoma. (a) Axial CT, (b) coronal CT.
MRI: No radiation, No nephrotoxicity

Renal MRU: 3-D image of the normal kidneys and ureters
Left ureteropelvic junction obstruction. MR Urogram in patient with UPJ obstruction shows dilatation of the left renal pelvis and calices.
IVP: not recommended routinely

Normal IVP
Urinary tract infections

Old approach to child with VUR

VUR

Grade 1-3

Prophylaxis, U/Cs

VCUG annually

Reflux

Resolved

Unchanged

Worse

DC Antibiotic

Continue Prophylaxis

Grade 4-5

Surgery
DMSA and VCUG have a high burden of radiation exposure, this is because National Institute for Health and Care Excellence (NICE) recommends protocols:

Top down or Bottom-up
VCUG and DMSA scans radiation:
Equivalent to 40–50 chest X-rays or 4 months of natural background Radiation.

A nationwide population-based retrospective cohort study in Taiwan found that the risk of cancer was 1.92-fold greater in children who had undergone VCUG compared with matched controls; the highest risk was for genital and urinary system cancers.

Recent digital X-rays have much less radiation.
Imaging protocols in Pediatric UTIs

Radiation exposure associated with some of the radiological investigations.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Radiation dose (mSv)</th>
<th>Background radiation (equivalent)</th>
<th>Chest X-ray (equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal X-ray</td>
<td>1.0</td>
<td>161 days</td>
<td>50</td>
</tr>
<tr>
<td>IVU</td>
<td>2.5</td>
<td>403 days</td>
<td>125</td>
</tr>
<tr>
<td>DMSA scan</td>
<td>1.0</td>
<td>161 days</td>
<td>50</td>
</tr>
<tr>
<td>CT abdomen/pelvis</td>
<td>10</td>
<td>1613 days</td>
<td>500</td>
</tr>
<tr>
<td>Ultrasound scan</td>
<td>0</td>
<td>0 days</td>
<td>0</td>
</tr>
<tr>
<td>MR scan</td>
<td>0</td>
<td>0 days</td>
<td>0</td>
</tr>
<tr>
<td>MCUG</td>
<td>1.5 (boys)/0.9 (girl)</td>
<td>242/145 days</td>
<td>75/45</td>
</tr>
</tbody>
</table>

### Imaging protocols in Pediatric UTIs

Radiological investigations following UTI in infants under 6 months of age.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Good response within 48 hours</th>
<th>Atypical UTI</th>
<th>Recurrent UTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>US at time of acute infection</td>
<td>No</td>
<td>Yes †</td>
<td>Yes</td>
</tr>
<tr>
<td>US within 6 weeks</td>
<td>Yes ‡</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DMSA at 4-6 months</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MCUG</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Imaging protocols in Pediatric UTIs

- Infants < 6 months with first time UTI that responds to treatment → US within 6 weeks
- Infants & children with first time UTI that responds to treatment → routine US not recommended unless UTI is atypical
- Infants & children with lower UTI → US within 6 weeks only if <6 months or had recurrent UTI
- NICE guideline 2007
Imaging protocols in Pediatric UTIs

Imaging for infants < 6 months

- Responds well to treatment within 48 hours → No DMSA, No MCUG
- Atypical UTI → DMSA yes, MCUG yes?
- Recurrent UTI → DMSA yes, MCUG no
**Imaging protocols in Pediatric UTIs**

Radiological investigations following UTI in children of 6 months to 3 years.

<table>
<thead>
<tr>
<th></th>
<th>Good response within 48 hours</th>
<th>Atypical UTI</th>
<th>Recurrent UTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>US at time of acute infection</td>
<td>No</td>
<td>Yes†</td>
<td>No</td>
</tr>
<tr>
<td>US within 6 weeks</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>DMSA at 4-6 months</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MCUG</td>
<td>No</td>
<td>No*</td>
<td>No*</td>
</tr>
</tbody>
</table>

*MCUG if dilatation on US, poor urine flow, non E. coli UTI, family history of VUR

†US at 6 weeks if non E.coli UTI, but responding well

Imaging protocols in Pediatric UTIs

Imaging for infants & children > 6 months but < 3 years

• Responds well to treatment within 48 hours → No imaging

• Atypical UTI → US during acute infection, DMSA

• Recurrent UTI → US within 6 weeks, DMSA

• NICE guidelines 2007
## Imaging protocols in Pediatric UTIs

Radiological investigations following UTI in children over 3 years of age.

<table>
<thead>
<tr>
<th></th>
<th>Good response within 48 hours</th>
<th>Atypical UTI</th>
<th>Recurrent UTI</th>
</tr>
</thead>
<tbody>
<tr>
<td>US at time of acute infection</td>
<td>No</td>
<td>Yes*</td>
<td>No</td>
</tr>
<tr>
<td>US within 6 weeks</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>DMSA at 4-6 months</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>MCUG</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

*US with full bladder (measure pre- and post-micturition volume)

†US at 6 weeks if non-E coli UTI, but responding well

Recommended imaging for children > 3 years

• Responds well to treatment within 48 hours → No imaging

• Atypical UTI → US during acute infection

• Recurrent UTI → US within 6 weeks, DMSA in 4-6 months

• NICE guidelines 2007
Atypical UTI

1. Seriously ill
2. Poor urine flow
3. Abdominal or bladder mass
4. Raised serum creatinine
5. Septicemia
6. Failure to respond to treatment with suitable antibiotics within 48 hours
7. Infection with non-E coli organisms
# Imaging protocols in Pediatric UTIs

Recommendations from clinical practice guidelines for routine investigations following urinary tract infection

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>&lt;6 months of age</td>
<td>6–36 months of age</td>
<td>2–24 months of age</td>
<td>2–36 months of age</td>
</tr>
<tr>
<td>Ultrasound during UTI</td>
<td>Yes if poor response to therapy/atypical UTI</td>
<td>No unless atypical UTI</td>
<td>Yes if very unwell</td>
<td>Yes if poor response to therapy</td>
</tr>
<tr>
<td>Later ultrasound</td>
<td>Yes</td>
<td>No</td>
<td>Yes if not unwell</td>
<td>Yes if not unwell</td>
</tr>
<tr>
<td>DMSA scan (at 4–6 months)</td>
<td>No unless atypical UTI</td>
<td>No unless atypical UTI</td>
<td>No recommendation</td>
<td>No unless abnormal US/VCUG</td>
</tr>
<tr>
<td>Voiding cystourethrogram</td>
<td>No unless atypical UTI/abnormal US</td>
<td>No unless US abnormal</td>
<td>No unless US abnormal</td>
<td>No unless US abnormal</td>
</tr>
</tbody>
</table>
Imaging protocols in Pediatric UTIs

NICE guidelines for imaging studies in children with UTI

**Top Down**

- **US** ➔ Normal ➔ **DMSA** ➔ Normal ➔ **STOP**

  - # Abnormal ➔ **VCUG**

**Bottom Up**

- **US** ➔ Abnormal ➔ **VCUG** ➔ Normal ➔ **STOP**

  - # Abnormal ➔ **DMSA**
Imaging protocols in Pediatric UTIs

Imaging studies for first urinary tract infection in infants less than 6 months old: can they be more selective? Niko Kei-chiu Tse¹, Sandy Lai-kei Yuen¹, Man-chun Chiu¹, Wai-ming Lai¹ and Pak-chiu Tong Ped Nephrology, 15 May 2009

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**Flow Chart:**

1. **Typical group (n = 98)**
   - NICE UTI Guidelines
     - Abnormal US 8 (including 1 PUJO)
       - MCUG
         - Abnormal 3 (all VUR): 5 refluxing ureters
           - late DMSA
             - Diagnosis of 4 scarred kidneys
           - Under-diagnosis of 3 scarred kidneys
         - Normal 4
           - No DMSA necessary
           - Under-diagnosis* of 25 refluxing ureters and 19 scarred kidneys
             - No further imaging necessary
   - Normal US 90

* Allogether 25 refluxing ureters & 22 scarred kidneys would have been missed with the application of the imaging strategies in the Guidelines.
Since the presence or severity of VUR does not influence the efficacy of treatment, **routine VCUG following the first UTI is no longer justified.**

The remaining clear indication for a VCUG is to evaluate the **bladder and urethra in children suspected of having obstructive uropathy secondary to conditions such as PUV.**
**Imaging protocols in Pediatric UTIs**

**NICE guidelines for imaging studies in children with UTI adequate only in boys under the age of 6 months**

Marko Tapani Ristola **Affiliated with** Turku University Hospital [Pediatric Surgery International], March 2013, Volume 29, Issue 3, pp 215-222

**Purpose:** To evaluate the applicability of the NICE guidelines for imaging studies in children under the age of three with first UTI.

If the NICE guidelines had been applied, 13 of the 25 patients (52 %) with vesicoureteral reflux (VUR), including 6 of the 12 patients (50 %) with dilating VUR and 3 of the 4 patients who underwent endoscopic anti-reflux treatment, would have been missed, and a negative VCUG would have been avoided in 25 of the 42 patients (60 %) with no VUR. None of the missed diagnoses occurred in the younger boys’ group.

**Conclusion**

Based on these preliminary analyses, we feel that the NICE guidelines for imaging studies in children under 3 years old with UTI may be applicable to clinical use only in boys under 6 months of age. For other patients the guidelines were unsuccessful.
The biggest change from the 1999 guideline is in the section on imaging.

**Action Statement 5:** Febrile infants and young children with UTI should undergo renal and bladder US
(Evidence Quality C; Recommendation.)

**Action Statement 6a:** Although VCUG should not be performed routinely after the first febrile UTI, it is indicated if renal and bladder ultrasonography reveals hydronephrosis, scarring, or other findings that suggest high-grade VUR or obstructive uropathy, and in other atypical or complex clinical circumstances. (Evidence Quality B; Recommendation.)

**Action Statement 6b:** Further evaluation should be conducted if there is a recurrence of febrile UTI. (Evidence Quality X; Recommendation.)
Although childhood UTI is common, the occurrence of CKD and the likelihood that acute pyelonephritis will cause renal damage progressing to CKD are.

By identifying this group of children with increased risk of having an abnormal urinary tract that warrant investigation, we recommend that targeting investigations to specific children (as opposed to protocol-based investigations of all children with UTI), will be clinically safe and effective and will avoid the unnecessary distress and cost of invasive investigations.
## Revised AAP Guideline: So

### AAP Clinical Practice Guideline on UTI in Febrile Infants and Young Children: Key Updates

<table>
<thead>
<tr>
<th>Area of management</th>
<th>Updates from the 1999 guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
<td>Both an abnormal urinalysis result and a positive urine culture result are needed to confirm inflammation. A positive culture result is defined as at least 50,000 colony-forming units per mL, rather than the previous criterion of at least 100,000 colony-forming units per mL. Guidance is added for using clinical criteria to establish a threshold to decide whether to obtain a urine specimen.</td>
</tr>
<tr>
<td>Treatment</td>
<td>Oral treatment is as effective as parenteral treatment.</td>
</tr>
<tr>
<td>Imaging</td>
<td>Voiding cystourethrography is not recommended routinely after the first febrile UTI; ultrasonography should include the bladder and the kidneys.</td>
</tr>
<tr>
<td>Follow-up</td>
<td>Emphasis is on urine testing with subsequent febrile illnesses, rather than on regularly repeated urine cultures after treatment.</td>
</tr>
</tbody>
</table>

**NOTE:** The guideline applies to infants and children two to 24 months of age with unexplained fever.

**AAP** = American Academy of Pediatrics; **UTI** = urinary tract infection.

*Information from reference 4.*
Imaging in Pediatric Urinary Tract Infections

Imaging: Procalcitonin

- Leroy 2013 and 2011 studies address the issues of utility of Procalcitonin in guiding decision making for imaging following first febrile UTI, specifically VCUG vs DMSA
- Procalcitonin may help predict upper vs lower tract disease and may help identify which patients are at risk for scarring
- However, procalcitonin may not be useful if drawn after start of therapy. Additionally, it is a send-out test with a lengthy turnaround time

Local consensus: Procalcitonin is not recommended at this time. Will re-evaluate in setting of further evidence.
Summary of our protocol:

Facing a pyelonephritis especially in a small child we suggest the use of U/S straight away and if the results are abnormal, VCUG can be used based on the bottom up policy and if U/S is normal then, DMSA scan is needed to see whether renal injury has developed (Top down).

If U/S is normal and the physician is concerned about renal scars a DMSA scan is done at the time of acute illness or six months later based on the patient and their family situation.

If there is severe renal involvement, then VCUG or DRNC or MRU may be indicated later.
We use VCUG when bladder imaging is indicated to see bladder in detail.
We use DRNC For Follow-up

To see if VUR has resolved?
Final conclusion:

- Consider the patient
- Individualize
- Avoid guideline prison
Thank you for your attention