Imaging in Urinary Tract Infections

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Medical Director, Pediatric Urology
What is a UTI?

• Definition not as clear as we would like.

• Dysuria alone is not UTI

• Positive culture alone is not UTI
  – > 50K pure culture

• 2-4 RBC/WBC is not UTI

• Dysuria+culture+leukocytes=UTI
“A diagnosis is not simply… (UTI)…but also must include appreciation of those factors—from the subcellular to the community—that underlie the disease or affect the treatment.”

Eric Cassell, MD
Urinary Tract Infection

• Requires a bacteria which can adhere to urothelium

E. coli with p-fimbriae
Scanning EM of E. coli on bladder wall
Host Factors

• Gender
  – Male: circumcision status
  – Female: diapers, labial adhesions

• Constipation

• Frequency of urination and total urine volume

• Incontinence

• ???
Pyelonephritis

• Urinary tract infection involving renal parenchyma
• Generally associated with systemic sx
  – Fever
  – Abdominal/Flank pain
  – Malaise
• Imaging most likely to be helpful
  – Cystitis rarely has anatomic basis
Why evaluate after UTI?

- Identify risk of recurrence
- Identify risk of renal injury
- Identify treatable predisposing conditions
- Evaluation
  - History
  - Physical Exam
  - Imaging
- What Imaging is available?
Available Imaging Modalities

- KUB
- Ultrasound
- CT scan w/wo contrast
- Voiding cystourethrogram (VCUG)
- Renal Scan (DMSA)
- Magnetic Resonance Urogram (MRU)

- What imaging is INDICATED?
KUB

- Quick, painless, low radiation dose
- Assess for constipation (subjective)
- Evaluate for calculi (>2-3 mm)
Renal Ultrasound

- Hydronephrosis, renal anatomy/scarring
- Bladder pathology (ureterocele)
- Ureteral pathology
- Constipation (rectal diameter)
- No radiation involved
- Most operator dependent of all imaging
- Cannot r/o vesicoureteral reflux
The Bladder

Ureterocele
Ureteral Jets
Hydronephrosis
Pyelonephritis

RT KIDNEY TRANS SUP

RT KIDNEY LONG PRONE SUP
CT Scan

- Definitive study for stones
- Can identify non renal pathology
- Relatively high radiation dose (ALARA)
- Not as operator dependent as US
- IV access needed for contrast
Pyelonephritis by CT
Voiding CystoUrethroGram

- Definitive study for vesicoureteral reflux
- Reasonable radiation dose *when done properly*
- Can provide information re: bladder function
- Invasive (urethral catheterization)
First Cystogram with VUR
Vesicoureteral Reflux
Bilateral Diverticuli
Unstable Bladder
Renal Scan

- Definitive for renal function, scarring
- Can be diagnostic for pyelonephritis
  - >90% accuracy based on animal models
- Requires sedation, IV
Normal DMSA Renal Scan
Renal Scarring

Decreased uptake with loss of renal contour or volume loss
Magnetic Resonance Urogram

- Non invasive
- No radiation
- Can determine obstruction and function
- Expensive
- Requires sedation
- Not available locally
Available Imaging Modalities

- KUB
- Ultrasound
- CT scan w/wo contrast
- Voiding cystourethrogram (VCUG)
- Renal Scan (DMSA)
- Magnetic Resonance Urogram (MRU)

What imaging is INDICATED?
“Technical procedures, valuable as they are when there is a rational basis for using them, are invoked mindlessly and automatically, as rituals to reassure anxious physicians.”

Bursztajn Et. Al.
Medical Choices, Medical Chances 1981
Imaging in UTI

• Easy question to answer
• Standard workup recommended for decades
  – Renal Ultrasound
  – Voiding Cystourethrogram (VCUG)
  – Maybe DMSA
• Goal to identify Vesicoureteral Reflux (VUR) and prevent renal scarring
Urinary Tract Infection: Clinical Practice Guideline for the Diagnosis and Management of the Initial UTI in Febrile Infants and Children 2 to 24 Months

PEDIATRICS Volume 128, Number 3, September 2011

SUBCOMMITTEE ON URINARY TRACT INFECTION, STEERING COMMITTEE ON QUALITY IMPROVEMENT AND MANAGEMENT
AAP Guidelines

• Meta analysis of research papers regarding the relationship between vesicoureteral reflux, antibiotic prophylaxis and recurrent febrile infection

• **Seven** recommendations regarding appropriate *diagnosis, management and subsequent evaluation* of young child with febrile UTI

• Subsequent evaluation only controversial recommendation
AAP UTI Guidelines

- Aim to enhance the clinical diagnosis of UTI in children 2 months to 2 years
- Rationalize the use of antibiotics for pediatric UTI
- No VCUG for initial febrile UTI with normal US
Section on Urology Response to New Guidelines for the Diagnosis and Management of UTI

Julian Wan, MD, Steven J. Skoog, MD, William C. Hulbert, MD, Anthony J. Casale, MD, Saul P. Greenfield, MD, Earl Y. Cheng, MD, and Craig A. Peters, MD, on behalf of the Executive Committee, Section on Urology, American Academy of Pediatrics

Pediatrics 2012;129;e1051; originally published online March 12, 2012;
Response to the AAP Section on Urology Concerns About the AAP Urinary Tract Infection Guideline

Kenneth B. Roberts, S. Maria E. Finnell and Stephen M. Downs

*Pediatrics* 2012;129;e1054; *originally published online March 12, 2012*

50% decrease in VCUG’s performed at GMH
Why no VCUG after first infection?

• Treatment of Vesicoureteral Reflux with prophylactic antibiotics does not prevent febrile UTI

• Treatment of VUR does not prevent renal injury

• Therefore, why make the diagnosis?
Urologists’ Main Issues with Guidelines

• Data and interpretation are flawed
• Guidelines are not “real-world”
Statistics: The science of producing unreliable facts from reliable figures.

Evan Esar
Evidence Based Medicine?

• How good is the evidence?

  ✓ wide age ranges (3 months-18 years)
  ✓ few patients with higher than grade II VUR
  ✓ variable culture methods (bag, cath, SP)
  ✓ low incidence of initial renal abnormalities,
  ✓ no assessment of medication compliance,
  ✓ no assessment of voiding dysfunction
Study biases?

• Many of the studies started with a diagnosis of VUR
• Parents and physicians were not blinded to the presence of VUR
• Their behavior reflects knowledge of VUR – they will likely act differently than if they did not know VUR was present
It is now widely recognized not only that urinary infection in childhood is a common and recurrent condition, but also that symptomatic improvement of the acute episode, whether soon results obtained by this method with pour-plate bacterising techniques. The report of a positive urine culture as by them corresponded closely with a growth of $10^3$ org.

**Figure 4.** Time to Urinary Tract Infection (UTI) with Fever (Secondary Outcome).
Swedish Reflux Trial:
J. Urol. 184:286, 2010

- Logrank p < 0.0001
- Time to first febrile recurrence (months)
- Probability of no UTI recurrence

1: Endoscopic
2: Prophylaxis
3: Surveillance
Swedish Reflux Study: New Renal Scarring at 2 years

Number of patients with new renal damage in 2 years FU
UTI incidence with CAP: Impact of Bowel Bladder Dysfunction (BBD)

Overall

UTI incidence (per 100 children)

BBD

No BBD

43% incidence if BBD present vs. 12% if no BBD
Guidelines are not “real world”
Adherence to AAP Practice Guidelines for Urinary Tract Infections at Our Teaching Institution

Lopa Shah, MD, Nandini Mandlik, DO, Payal Kumar, MD, Serjun Andaya, MD, and Pisespong Patamasucon, MD

Urinary tract infection (UTI) in children is a common diagnosis in general pediatric practice. Because of the potential severity and neuro-morbidity of such infec- 

AAP. It is found that at the a- tions, there is at least 70% a- mendations for method of m-

• 70% adherence to recommended method of urine collection

• 61% adherence to recommended imaging work-up
Why evaluate a child after a febrile UTI?

• Identify risk of recurrence
• Identify risk of renal injury
• Identify treatable contributors
• Can we eliminate all risk? NO
• Can we reduce risk? YES
• What is an acceptable threshold for risk and how much are we willing to “pay” for this in testing morbidity, cost, false positives, etc.?
Risk thresholds

• “We over-treat in order to avoid under-treatment”
• What level of risk is acceptable and how do we measure the impact over time?
• Who should determine the level of acceptable risk?

✓ Patients/parents? ✓ Government?
✓ Physicians? ✓ Insurance companies?
What is the risk of missing reflux?

- Overall scarring incidence is “low”
- Is it low enough?
- Coulthard *Ped Nephrol* 2009 – scarring can be severe
- Grade of reflux correlates with scarring
- More episodes of infection correlate with increased incidence of scarring
- Delays in therapy can be associated with more renal injury
New scars in refluxing children usually seen with delayed treatment, absence of antibiotic prophylaxis, and social problems

**TABLE II—**Maximum observed grade of vescoureteric reflux related to extent and development of new scarring in 87 kidneys

<table>
<thead>
<tr>
<th>Maximum observed grade of reflux</th>
<th>Total No of kidneys</th>
<th>No of new scars/kidney</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>15*</td>
<td>9</td>
</tr>
<tr>
<td>I</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>II</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>III</td>
<td>36</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>87</td>
<td>52</td>
</tr>
</tbody>
</table>

*In seven ureters the first micturating cystourethrogram was delayed for more than two years.
Purpose: We studied the relationship among vesicoureteral reflux, urinary tract infection and permanent renal damage in children.

Materials and Methods: We retrospectively analyzed 303 children younger than 2 years with a first time, nonobstructive.

Number of UTIs and percent with DMSA abnormalities

VUR grade and risk of DMSA abnormalities

Problems with Guidelines

• Sex and Circumcision Status
  – Pennesi: 50% male, all uncircumcised*
  – Garin: 17% male, unknown
  – Montini: 31% male, unknown*
  – Roussey-Kesler: 31% male, unknown*
  – Craig: 36% male, 4% circumcised*
  – Brandström: 37% male, unknown*

* Circumcision not widely practiced – skews culture results
Problems 2

- Bagged Urine Specimens used in the studies:
  - Pennesi
  - Montini
  - Roussey-Kesler
  - Craig
  - Brandström

- Catheterized Urine Specimens:
  - Garin

- A major concern especially in uncircumcised males
Problems 3

• Age
  – Brandström: 1-2 year olds
  – Craig: median age 14 months, 37% older than 2 years, 23% were between 4 and 15 years
  – Garin: 1 mo to 18 years, median in abx and no-abx group was 2 years old, PN patient age unknown
  – Montini: median 10.2 months (1-8.4 years)
  – Pennesi: mean 9 months, (2-84 months)
  – Roussey-Kesler: median 1 yr, ± SD: 8.4 mos

• Older patients: ? bladder/bowel dysfunction (BBD)
Problems 4

• US can’t determine scarring
  – Tasker AD et al, Clin Radiol 47: 177, 1993

• US can’t predict VCUG results

• DMSA scans not uniformly performed
  – Pennesi
  – Roussey-Kesler
  – Craig

• VCUG and US not performed on all patients
  – Craig

• Incomplete imaging - Who really has what? Who really had scarring?
• Compliance of antibiotic regimen NOT assessed
  – Pennesi (yes in those with recurrent UTI, 100%!?)
  – Garin
  – Roussey-Kesler
  – Craig
  – Brandström

• Montini: Yes, 71% compliance

• No Prophylaxis versus Non-Compliance isn’t the same as Prophylaxis versus No Prophylaxis
Problems 6

• Blinded or placebo controlled:
  – Craig

• None of the other studies were blinded or conducted with placebo
  – Pennesi
  – Montini
  – Roussey-Kesler
  – Garin
  – Brandström
Problems 7

- Pennesi: no benefit to prophylaxis
- Garin: no benefit
- Montini: prophylaxis may benefit grade III
- Roussey-Kesler: prophylaxis may benefit boys with grade III
- Craig: febrile UTI double in those not on prophylaxis
- Brandström: prophylaxis provides clear benefit, no new scarring on prophylaxis
- Contradictory conclusions – yet Guidelines declares otherwise...
VCUG at Children’s Hospital

- Pre-VCUG Child Life Specialist phone call
- VCUG prep booklet
  - [http://www.ghs.org/upload/docs/Healthy%20Living/VCUG.pdf](http://www.ghs.org/upload/docs/Healthy%20Living/VCUG.pdf)
- > 18 months Child Life Specialist
- > 18 months oral Versed
- Pediatric specialty staff
- Environmental decor
- Physician expertise
Bottom Line

• AAP UTI Guidelines have significant problems with methodology and conclusions

• Antibiotic prophylaxis can be helpful in appropriate patient

• VCUG need not be terrible experience

• Statistics are no substitute for judgment
  – Henry Clay
Recommendations

• Renal US and VCUG for all children with pyelonephritis (febrile UTI)
• Renal Scan (DMSA) if renal US abnormal or high grade reflux identified
• Antibiotic prophylaxis for high grade (>2) reflux
• Always evaluate for bowel and bladder dysfunction in continent children with UTI