How to Predict the Development of Severe Renal Lesions in Children with febrile UTI?

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Head of Pediatric Nephrology
“P. & A. Kyriakou” Children’s Hospital, Athens, Greece
Long term complications of VUR

The presence of VUR increased the risk of renal damage by about 20%

Cumulative incidence of symptomatic UTIs

At the age of 7 years (1982)
3553 children entered school in Goteborg

**Girls:** 8.4%

**Boys:** 1.7%

1 out of 12 girls had a history of UTI at the age of 7 years

*Hellstrom A et al. Acta Paediatr 1991*
Cumulative incidence of symptomatic UTIs

At the age of 7 years (1982)
3553 questionnaires were completed

Previous UTI was reported in:
274 (7.7%) children
66 (1.8%) with UTI with fever

• Acute pyelonephritis (APN)
• Acute cystitis (AC)
• Unspecified

Fever (>38.5 °C) is considered a marker of renal parenchyma involvement.
Age at the first recognized UTI

Uncircumcised
Boys (N=225)

Age at the first recognized UTI

Uncircumcised Boys (N=225)

Girls (N=952)

Number of patients

Age (years)

Number of patients

Age (years)

Febrile UTI

- Acute pyelonephritis (APN)
- Acute cystitis

The nonspecific nature of symptoms makes the clinical differentiation difficult. Especially, in children <3 months

DMSA scan: the gold standard for APN diagnosis
50%–80% of children with febrile UTI have lesions at the DMSA

*Rushton HG Pediatr Nephrol 1997*
275 children

Renal scars were found only in children with abnormal findings on the acute DMSA scan.

- 60% of acute DMSA scans showed renal lesions.
- 9.5% of children had abnormal findings after 6 months.

Can we predict the development of renal lesions?

The goal: identification of children at high risk of severe renal lesions after febrile UTI.

Selective imaging investigation and management.

One size does NOT fit all.

Siomou E, Stefanidis CJ Ped Nephrol 2007
Can we predict the development of renal lesions?

Clinical findings
- Duration of fever
- Other

Biochemical findings
- Raised s. creatinine

Imaging
- Presence of VUR

Biomarkers of kidney inflammation
- WBCs
- CRP
- PCT
VUR is rare in normal children (2%).

VUR is frequent in children with fUTI (30-40%).

VUR was considered the major factor in the pathogenesis of febrile UTI and renal scarring.
VUR and APN

VUR and bacteria in the pelvis lead to inflammation and scarring of the renal parenchyma.
Pathophysiology of acute pyelonephritis

E. Coli with p.fibria

Lipopolysaccharide (endotoxin)

Toll-like receptor

CD14

Uroepithelial cell

Pathophysiology of acute pyelonephritis

E. Coli with p.fibria

Lipopolysaccharide

Toll-like receptor

CD14

Through subsequent steps

Activation of nuclear factor κB

Pathophysiology of acute pyelonephritis

Nuclear factor κB

Cytoplasm

Nucleus

Inflammatory factors

Interleukin-6

Fever

Pathophysiology of acute pyelonephritis

Cytoplasm

Nucleus

Nuclear factor κB

Inflammatory factors

Interleukin-6

Interleukin-8

Fever

↑ Neutrophil recruitment

Pathophysiology of acute pyelonephritis

Nuclear factor κB

Inflammatory factors

Interleukin-6

Interleukin-8

TNF-α

Fever

↑ Vascular permeability and inflammation

↑ Neutrophil recruitment

Pathophysiology of acute pyelonephritis

- Nuclear factor \( \kappa B \)
- TNF-\( \alpha \)
- TGF-\( \beta \)
- Prostaglandins
- Interleukin-6
- Interleukin-8
- Scar formation

Inflammatory factors

- Fever
- Neutrophil recruitment
- Vascular permeability and inflammation

Cytoplasm

Nucleus
Permanent renal lesions related with fUTIs

Girls

- Acquired lesions after recurrent UTIs
- Usually diagnosed in older age
- Usually with low grades of VUR (or no VUR)
- Bladder dysfunction
Permanent renal lesions related with VUR

Boys

- Congenital renal lesions (hypoplasia – dysplasia)
- Usually diagnosed < 1\textsuperscript{st} year of age
- Usually with high grades of VUR
- At low risk to develop acquired lesions
VUR is a risk factor for APN?
Vesicoureteral reflux as a risk factor for acute pyelonephritis and renal damage in children with UTI: systematic review and meta-analysis

Association high grade VUR/APN

80 studies
11,410 patients
(mean age 1.9 years)
Association high grade VUR/APN

Relative risk of acute pyelonephritis

- Reference: 1.0
- VUR: 2 (1.8-2.3)
- VUR IV V: 4.1 (2.8-5.9)

Recurrent Urinary Tract Infections in Children: Risk Factors and Association With Prophylactic Antimicrobials

Children aged 6 years or younger with at least 2 clinic visits

- 775 With record of urinary tract infection

- 164 Excluded
  - 91 Previous UTI
  - 55 Observation time <24 d
  - 17 Comorbid conditions
  - 1 UTI diagnosed by bag specimen

- 611 With first UTI included in analysis

- 83 With recurrent UTI

27 primary care pediatric practices (2001-2006)

13%
Association high grade VUR/ APN

Recurrence Urinary Tract Infections in Children: Risk Factors and Association With Prophylactic Antimicrobials

Patrick H. Conway; Avital Cnaan; Theoklis Zaoutis; et al.


Relative Risk of APN

- Reference: 1.0
- VUR: 2 (1.8-2.3)
- VUR IV V: 4.1 (2.8-5.9)
Association high grade VUR/ recurrent UTI

Relative Risk of recurrent UTI

<table>
<thead>
<tr>
<th>Reference</th>
<th>VUR I II III</th>
<th>VUR IV V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.17 (0.52-2.66)</td>
<td>4.59 (1.36-15.47)</td>
</tr>
</tbody>
</table>
VUR is a risk factor for renal scars?
1533 references identified
546 from Medline
949 from Embase
38 from review of references

1205 references

328 references retrieved

295 references excluded
  90  UTI not required for inclusion
  59  Not first UTI
  34  DMSA timing did not meet criteria
  30  Insufficient data to calculate prevalence
  27  Duplicate studies
  21  Urine culture criteria not met
  9  Case series (n < 25)
  8  Loss to follow-up >15%
  8  Study included adults
  5  Used SPECT DMSA
  5  Results according to kidney, not child

33 references included in analysis
Renal lesions and VUR

<table>
<thead>
<tr>
<th>Study</th>
<th>Risk Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oh et al(^{22}) (2008)</td>
<td>2.29 (1.31–4.02)</td>
</tr>
<tr>
<td>Chroustova et al(^{28}) (2006)</td>
<td>7.08 (4.38–11.44)</td>
</tr>
<tr>
<td>Taskinen and Ronnholm(^{30}) (2005)</td>
<td>1.05 (0.33–3.34)</td>
</tr>
<tr>
<td>Zaki et al(^{14}) (2005)</td>
<td>1.22 (0.74–2.00)</td>
</tr>
<tr>
<td>Camacho et al(^{34}) (2004)</td>
<td>10.31 (3.52–30.24)</td>
</tr>
<tr>
<td>Hoberman et al(^{19}) (2003)</td>
<td>2.47 (1.16–5.23)</td>
</tr>
<tr>
<td>Panaretto et al(^{45}) (1999)</td>
<td>2.96 (1.63–5.39)</td>
</tr>
<tr>
<td>Jakobsson and Svensson(^{5}) 1997</td>
<td>1.94 (1.33–2.84)</td>
</tr>
<tr>
<td>Stokland et al(^{4}) (1996)</td>
<td>2.23 (1.53–3.24)</td>
</tr>
<tr>
<td>Overall</td>
<td>2.62 (1.74–3.94)</td>
</tr>
</tbody>
</table>
Renal lesions and VUR

<table>
<thead>
<tr>
<th>Study</th>
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</tr>
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<td>Hoberman et al\textsuperscript{19} (2003)</td>
<td>1.32 (0.53–3.27)</td>
</tr>
<tr>
<td>Panaretto et al\textsuperscript{45} (1999)</td>
<td>3.94 (1.60–9.71)</td>
</tr>
<tr>
<td>Jakobsson and Svensson\textsuperscript{5} (1997)</td>
<td>2.57 (1.42–4.63)</td>
</tr>
<tr>
<td>Stokland et al\textsuperscript{4} (1996)</td>
<td>1.69 (0.99–2.88)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>2.13 (1.43–3.16)</strong></td>
</tr>
</tbody>
</table>
Dilating VUR (grade III, IV, V) is a risk factor for the development of renal lesions
Natural history of VUR: population of 1,000,000 children

Mcllroy PJ et al.  
*J Paediatr Child Health* 36 : 569 –573, 2000

http://jasn.asnjournals.org/cgi/content/full/19/5/847

- **VUR** 30,000
  - UTI 6,000
    - Recurrent UTI 2,000
  - No UTI 24,000
  - **Renal “scarring”** 10,000
    - Hypertension? 5
  - **ESRD**
1221 children followed from first UTI

Follow-up after 16-26 years

Renal function well preserved (> GFR 70 ml/min/1.73m²)


No increased risk of hypertension

Wennerström et al  J Hypertension 2000;18:485-91
1221 children followed from first fUTI

Mean follow-up 41 years

Renal function decreased from a mean of 93 ml/min/1.73m² to 81 ml/min/1.73m²

This decrease was found only in women with severe bilateral renal scarring

Importance of VUR
Importance of VUR
Can we predict the development of renal lesions?

**Clinical findings**
- Duration of fever
- Other

**Biochemical findings**
- Raised s. creatinine

**Imaging**
- Presence of VUR

**Biomarkers of kidney inflammation**
- WBCs
- CRP
- PCT
Clinical predictors of scarring after fUTI

Do systemic symptoms predict the risk of kidney scarring after urinary tract infection?

<table>
<thead>
<tr>
<th>Groups of children</th>
<th>(1) &lt;6 months</th>
<th>(2) 6 months to 3 years</th>
<th>(3) &gt;3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children with scars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Girls</td>
<td>3</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Children without scars</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>9</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Girls</td>
<td>11</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>63</td>
<td>57</td>
</tr>
</tbody>
</table>

*Coulthard MG et al. Arch Dis Child 2009*
Clinical predictors of scarring after fUTI

Do systemic symptoms predict the risk of kidney scarring after urinary tract infection?  

No

<table>
<thead>
<tr>
<th>Age group</th>
<th>Vomiting, anorexia, malaise</th>
<th>Hospitalised</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensitivity</td>
<td>Specificity</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>(1) &lt;6 months</td>
<td>0.78 (0.60)</td>
<td>0.25</td>
</tr>
<tr>
<td>(2) 6 months–3 years</td>
<td>0.62 (0.58)</td>
<td>0.56</td>
</tr>
<tr>
<td>(3) &gt;3 years</td>
<td>0.43 (0.33)</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Low specificity of clinical findings

Coulthard MG et al. Arch Dis Child 2009
Clinical and laboratory indices of severe renal lesions in children with febrile urinary tract infection

AM Koufadaki, KA Karavanaki, A Soldatou, Ch Tsentidis, MP Sourani, T Sdogou, FA Haliotis, CI Stefanidis

Medical records with the diagnosis of “febrile UTI” (period 2002 – 2004)
n = 290 children

Missing data (n = 10)

n = 280

Obstructive uropathy (n = 10)

n = 270

Missing acute DMSA (n = 96)

n = 174

Previous episode of UTI (n = 26)

Total number of patients n = 148 children
Clinical and laboratory indices of severe renal lesions in children with febrile urinary tract infection

AM Koufadaki¹, KA Karavanaki (kkarav@yahoo.gr)¹, A Soldatou¹, Ch Tsentidis¹, MP Sourani², T Sdogou¹, FA Haliotis², CI Stefanidis³

Among several common symptoms associated with febrile UTI shivering was the only clinical sign predictive (Odds Ratio = 4.3) of acute renal lesions in DMSA scan.
Clinical predictors of scarring after fUTI

Clinical findings:
Gastrointestinal (vomiting, diarrhea) and/or Neurological symptoms (irritability, seizures)
Fever (≥38°C)

<table>
<thead>
<tr>
<th>Age</th>
<th>DMSA positive</th>
<th></th>
<th>DMSA negative</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>3–6 months</td>
<td>18</td>
<td>15</td>
<td>35</td>
<td>15</td>
</tr>
<tr>
<td>6–12 months</td>
<td>12</td>
<td>19</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>12–18 months</td>
<td>1</td>
<td>18</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>18–24 months</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>58</td>
<td>55</td>
<td>39</td>
</tr>
</tbody>
</table>

*DMSA* dimercaptosuccinic acid renal scan

Clinical predictors of scarring after fUTI

Do systemic symptoms predict the risk of kidney scarring after urinary tract infection?

No

Low specificity of clinical findings


<table>
<thead>
<tr>
<th></th>
<th>DMSA positive</th>
<th>DMSA negative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>8.9±5.8</td>
<td>7.0±5.9</td>
<td>0.019</td>
</tr>
<tr>
<td>Fever</td>
<td>39.6±0.7</td>
<td>39.2±1.2</td>
<td>0.114</td>
</tr>
<tr>
<td>GI symptoms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td>10 (11%)</td>
<td>21 (22%)</td>
<td>0.038</td>
</tr>
<tr>
<td>Vomiting</td>
<td>32 (35%)</td>
<td>31 (33%)</td>
<td>0.753</td>
</tr>
<tr>
<td>Irritability</td>
<td>12 (13%)</td>
<td>7 (7%)</td>
<td>0.198</td>
</tr>
<tr>
<td>Seizures</td>
<td>4 (4%)</td>
<td>7 (7%)</td>
<td>0.380</td>
</tr>
<tr>
<td>URI symptoms</td>
<td>10 (11%)</td>
<td>16 (17%)</td>
<td>0.237</td>
</tr>
</tbody>
</table>
Renal inflammatory changes were developed in 41% of the infants treated < 24 hours since the onset of fever, versus 75% of those treated > day 4. This difference was significant.
Risk factors for renal scaring

**Delayed treatment of the first febrile urinary tract infection in early childhood increased the risk of renal scarring**

Kyriaki A. Karavanaki¹, Alexandra Soldatou (alex_soldatou@hotmail.com)¹, Athina Maria Koufadaki¹, Charalampos Tsentidis¹, Fotis A. Haliotis², Constantinos J. Stefanidis³

### Table 3

<table>
<thead>
<tr>
<th>FBT (hours)</th>
<th>Lesions in repeat DMSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absent</td>
</tr>
<tr>
<td>&lt;72</td>
<td>16</td>
</tr>
<tr>
<td>≥72</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>16 (32%)</td>
</tr>
</tbody>
</table>

Fisher’s exact test, p = 0.014

Risk factors for renal scaring

Delayed treatment of the first febrile urinary tract infection in early childhood increased the risk of renal scarring

Kyriaki A. Karavanaki¹, Alexandra Soldatou (alex_soldatou@hotmail.com)¹, Athina Maria Koufadaki¹, Charalampos Tsentidis¹, Fotis A. Haliotis², Constantinos J. Stefanidis³

Table 4 Comparison of the data of patients with normal and abnormal repeat DMSA (rDMSA)

<table>
<thead>
<tr>
<th></th>
<th>Normal rDMSA (n = 88)</th>
<th>Abnormal rDMSA (n = 34)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (months)</td>
<td>3.3 ± 2.9</td>
<td>5.4 ± 5.0</td>
<td>0.07*</td>
</tr>
<tr>
<td>Gender</td>
<td>67% boys</td>
<td>66% boys</td>
<td>0.524**</td>
</tr>
<tr>
<td>FBT ≥72 hours</td>
<td>8/88 (9%)</td>
<td>10/34 (29%)</td>
<td>0.006**</td>
</tr>
<tr>
<td>WBC (/μL)</td>
<td>15 356 ± 5589</td>
<td>18 207 ± 7455</td>
<td>0.076*</td>
</tr>
<tr>
<td>ANC (/μL)</td>
<td>7172 ± 3834</td>
<td>9594 ± 5543</td>
<td>0.021*</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td>50.6 ± 47</td>
<td>76.2 ± 78.1</td>
<td>0.09*</td>
</tr>
<tr>
<td>PCT (ng/mL)</td>
<td>1.4 ± 1.9</td>
<td>7.5 ± 6.8</td>
<td>0.001*</td>
</tr>
<tr>
<td>Presence of VUR</td>
<td>11/88 (12%)</td>
<td>12/34 (35%)</td>
<td>0.004**</td>
</tr>
</tbody>
</table>

Delayed treatment of the first febrile urinary tract infection in early childhood increased the risk of renal scarring

Kyriaki A. Karavanaki, Alexandra Soldatou, Athina Maria Koufakaki, Charalampos Tsentidis, Fotis A. Haliotis, Constantinos J. Stefanidis

Table 5  Multiple regression analysis of several predictive factors of renal scarring

<table>
<thead>
<tr>
<th>Factor</th>
<th>Coefficient</th>
<th>SE (coef.)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.0104647</td>
<td>0.032503</td>
<td>0.32</td>
<td>0.75</td>
</tr>
<tr>
<td>Gender</td>
<td>0.0324836</td>
<td>0.1725102</td>
<td>0.19</td>
<td>0.85</td>
</tr>
<tr>
<td>WBC</td>
<td>-0.0000243</td>
<td>0.0000219</td>
<td>-1.11</td>
<td>0.28</td>
</tr>
<tr>
<td>ANC</td>
<td>0.0000137</td>
<td>0.000023</td>
<td>0.6</td>
<td>0.55</td>
</tr>
<tr>
<td>CRP</td>
<td>0.0016707</td>
<td>0.0017497</td>
<td>0.95</td>
<td>0.35</td>
</tr>
<tr>
<td>PCT</td>
<td>0.0555669</td>
<td>0.0343349</td>
<td>1.62</td>
<td>0.12</td>
</tr>
<tr>
<td>US</td>
<td>0.0768182</td>
<td>0.1904585</td>
<td>0.4</td>
<td>0.69</td>
</tr>
<tr>
<td>VUR</td>
<td>0.0402307</td>
<td>0.1992841</td>
<td>0.2</td>
<td>0.84</td>
</tr>
<tr>
<td>FBT ≥72 hours</td>
<td>0.6293513</td>
<td>0.1925352</td>
<td>3.27</td>
<td>0.005</td>
</tr>
</tbody>
</table>

Data from 2 longitudinal studies:
- Randomized Intervention for Children with VUR (RIVUR) (n = 607)
- Careful Urinary Tract Infection Evaluation Study (CUTIE) (n = 195)
A delay of 48 hours or more would increase the odds of new renal scarring by about 47%.
Risk factors for new renal scarring

- Older age
  (OR, 1.03; 95%CI, 1.01-1.05)
- Hispanic ethnicity
  (OR, 5.24; 95%CI, 2.15-12.77)
- Recurrent urinary tract infections
  (OR, 0.97; 95%CI, 0.27-3.45)
- Bladder and bowel dysfunction
  (OR, 6.44; 95%CI, 2.89-14.38)

Delay in the initiation of antimicrobial therapy remained significantly associated with renal scarring even after adjusting for these variables.

Shaikh N et al. JAMA Pediatr 2016
The predictors of new/progressive renal scar formation were:

- the presence of previous renal scarring
- greater number of UTIs
Can we predict the development of renal lesions?

Clinical findings
- Duration of fever
- Other

Biochemical findings
- Raised s. creatinine

Imaging
- Presence of VUR

Biomarkers of kidney inflammation
- WBCs
- CRP
- PCT
PCT and APN

627 children from 10 studies

Pooled diagnostic odds ratio of serum PCT for APN: 14.2 (95% confidence interval, 4.70 to 43.23)

Mantadakis E et al. Pediatr 2009
A total of 1011 patients APN in 60.6%, late scarring in 25.7%
Biomarkers APN Renal scars

Cut off value: 0.5 ng/mL

APN

OR 7.9 (5.8–10.9)
71% sensitivity
72% specificity

Renal scars

OR: 3.4 (2.1–5.7)
79% sensitivity
50% specificity
Validation studies are needed to derive an evidence-based clinical decision rule to identify children at high risk of renal scarring after UTI and selectively perform late DMSA-scan
Procalcitonin, C-reactive protein, and erythrocyte sedimentation rate for the diagnosis of acute pyelonephritis in children (Review)

Shaikh N, Borrell JL, Evron J, Leeflang MMG

Shaikh N et al. Cochr libr 2015
A low CRP < 20 mg/L appears to be somewhat useful in ruling out APN (decreasing the probability of APN to < 20%).

The PCT seems better suited for ruling in APN, but the limited number of studies and the marked heterogeneity between studies prevents us from reaching definitive conclusions.
At present, we do not find any compelling evidence to recommend the routine use of any of these tests in clinical practice
Can we predict the development of renal lesions?

**Clinical findings**
- Duration of fever
- Other

**Biochemical findings**
- Raised s. creatinine

**Imaging**
- VCUG
- DMSA
- Renal US

**Biomarkers of kidney inflammation**
- WBCs
- CRP
- PCT

Raised s. creatinine
Predictors of scarring after the first UTI

Identification of Children and Adolescents at Risk for Renal Scarring After a First Urinary Tract Infection
A Meta-analysis With Individual Patient Data

Single meta-analytic logistic regression model with data of 1280 patients

Patients: 1280 children with first diagnosed UTI

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bressan et al, 2009</td>
<td>72</td>
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<td>Craig et al, 1998</td>
<td>304</td>
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<td>Hoberman et al, 1999</td>
<td>309</td>
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<td>Kotoula et al, 2009</td>
<td>57</td>
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<tr>
<td>Levchenko et al, 2001</td>
<td>80(^a)</td>
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<tr>
<td>Montini et al, 2007</td>
<td>450(^b)</td>
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<td>Prat et al, 2003</td>
<td>77</td>
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<tr>
<td>Taskinen and Rönholm, 2005</td>
<td>62(^c)</td>
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<tr>
<td>Tuerlinckx et al, 2005</td>
<td>68(^d)</td>
</tr>
</tbody>
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Factors associated with renal scarring

(listed in descending order of importance)

- Grade IV or V VUR
  (22 times higher than in children with no VUR)
- Abnormal ultrasonographic findings
- C-reactive protein (>40mg/L)
- Temperature (>39°C)
- Organism other than E coli
- Polymorphonuclear cell count (>60%)

Take home messages

Children at risk to develop renal lesions after fUTIs:

- Increased serum CRP (>40 mg/L)
- PCT (>1 ng/ml)

The combination of:

- abnormal renal ultrasonography
- an etiologic organism other than E coli
- fever > 39°C
Take home messages

High risk group to develop renal lesions after fUTIs:

Children with: dilating vesicoureteral reflux
  recurrent fUTIs
  acquired renal scarring
High risk group to develop long term complications are children with extensive bilateral lesions