

Urinary Tract Infection (UTI) v.2: Criteria and Definitions

[Executive Summary](#)

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Inclusion Criteria

- Birth to 18 years, with a corrected gestational age of at least 40 weeks, with presumed or definite UTI (not a recurrent UTI)
- Children with nephrolithiasis are included, but will require nephrology follow-up

Exclusion Criteria

- Prior history of UTI
- Chronic kidney disease as defined by estimated glomerular filtration rate (GFR) by the original Schwartz formula $< 80 \text{ mL/min/1.73m}^2$
- Genitourinary abnormalities, including: previous genitourinary surgery (other than circumcision), neurogenic bladder conditions, known obstructive uropathy, known high-grade vesicoureteral reflux (Grades IV-V)
- Septic shock
- Presumed or definite meningitis
- Conditions requiring Intensive Care Unit care
- Immunocompromised host
- Pregnancy
- Recent history of sexual abuse

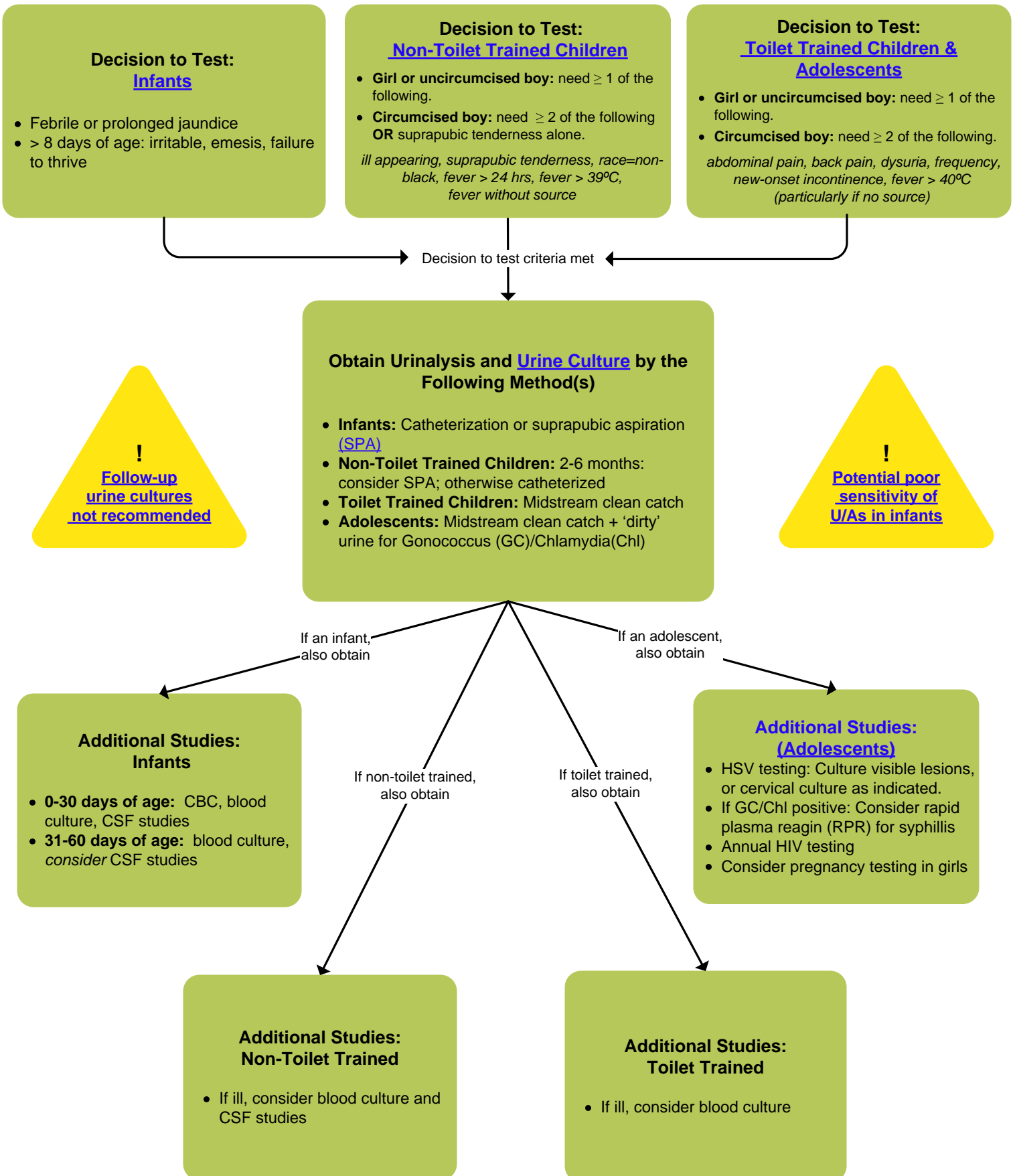
Atypical Versus Typical UTI

An atypical UTI, is defined as a UTI with one of the following properties:

- Seriously ill
- Poor urine flow: oliguria not due to dehydration, or urinary retention; urine output less than 1 mL/kg/hour
- Abdominal or bladder mass
- Elevated creatinine (eGFR $< 80 \text{ mL/min/1.73 m}^2$)
- Septicemia
- Failure to respond to treatment with suitable antibiotics within 48 hours [Committee interpretation: Treatment failure or persistent bacteremia]
- Infection caused by organism other than Escherichia coli

A typical UTI is defined as a UTI without any of these conditions.

Urinary Tract Infection v.2: Diagnosis



Urinary Tract Infection v.2: Treatment

Admit Criteria

All Age Categories

- Toxic appearance
- Dehydration requiring IV fluids
- Adherence risk as defined by: unable to take previously prescribed regimen, no reliable caregivers at home, Inability to follow recommended care plan, or at risk for loss to follow-up
- Failed outpatient therapy as defined by: persistent clinical symptoms beyond 48 hours on appropriate therapy, or inability to maintain hydration status

Infants

- Admit all patients up to 30 days of age with [presumed or definite](#) UTI.
- Admit all febrile patients 31-60 days of age with presumed or definite UTI

Adolescents

- Adherence risk is not an admission criteria for adolescents with cystitis.

Outpatient mgt, begin therapy for [presumed UTI](#)

Inpatient management, begin therapy for [presumed UTI](#)

Outpatient Management: Infants (31-60 days)

- Intramuscular (IM) ceftriaxone
- Follow up with primary care provider within 24 hours
- Narrow coverage when sensitivities return

Outpatient Management: Infants (31-60 days), Non-Toilet Trained Children, Toilet Trained Children & Adolescents

- [PO cephalexin or cefuroxime \(rationale\)](#), OR PO trimethoprim/sulfamethoxazole (if cephalosporin allergy) OR IM ceftriaxone
- Narrow coverage when sensitivities return

Inpatient Management: Infants (0-30 days)

- IV ampicillin + gentamicin OR IV ampicillin + cefotaxime
- [Switch Therapy](#): 7 days IV, then 7 days PO antibiotics
- Switch to PO if responding and after identification and sensitivities return; narrow coverage if possible

Inpatient Management: Infants (31-60 days)

- IV ceftriaxone OR IV ampicillin + gentamicin if cocci/enterococcus is suspected
- IV antibiotics until afebrile X 24 hrs (minimum 36 hours IV with negative blood cultures)
- Switch to PO if responding after identification and sensitivities return; narrow coverage if possible
- Total duration of antibiotics: 14 days

Inpatient Management: Non-Toilet Trained Children, Toilet Trained Children & Adolescents

- IV ceftriaxone OR IV ampicillin + gentamicin if cocci/enterococcus is suspected
- Switch to PO if responding after identification and sensitivities return; narrow coverage if possible
- Total duration of antibiotics: adolescents (7 days), toilet trained (7-14 days), non-toilet trained (10-14 days)
- 3 days for adolescent with [cystitis](#)

Evaluate for discharge

Discharge Criteria

General discharge criteria for all patients

- Clinical response to therapy
- Social risk factors assessed and addressed
- Family education provided/completed
- Urine culture is negative on final report OR if urine culture is positive and patient is on targeted antibiotics

Infants: General criteria and

- Afebrile (T < 38C) for 24 hours
- Other studies for occult bacteremia and meningitis are negative (if applicable)
- Able to maintain hydration status
- Tolerating planned home therapy
- Renal ultrasound completed or pre-natal ultrasound reviewed
- If indicated, VCUG completed or scheduled
- Consultation arranged if desired (e.g. may consider nephrology or urology consultation if imaging studies abnormal)
- If continuing on outpatient gentamicin, creatinine and gentamicin levels checked

Non-toilet trained and toilet trained children

- Afebrile (T < 38C) for 12 hours
- Imaging studies scheduled as indicated

Adolescents

- Completion of or plan for additional sexually transmitted infection (STI) testing as indicated

! Consider further imaging if no improvement in 48 hrs

! If blood culture (+), a minimum of 7 ds of IV antibiotics is recommended

Urinary Tract Infection v.2: Imaging Recommendations

Age Category?

Infant
or non-toilet trained

Toilet-trained
or adolescent

Imaging Recommendations: Infants and Non-toilet Trained Children

Renal Ultrasound (RUS)

- Can skip RUS if high quality third trimester U/S is normal

VCUG if:

- Atypical UTI (seriously ill, poor urine flow (< 1 ml/kg/hr), mass, increased creatinine (eGFR < 80), treatment failure, non-E. coli) **OR**
- RUS shows: hydronephrosis (pelvocaliectasis), renal parenchymal loss, kidney size discrepancies

DMSA Scan in 12 months after UTI if:

- < 6 months of age with atypical UTI **OR**
- Renal ultrasound shows evidence for renal parenchymal loss or kidney size discrepancies

Imaging Recommendations: Toilet-trained Children and Adolescents

Renal Ultrasound

- For boys with first UTI, or girls with atypical UTI

VCUG if:

- Atypical UTI (seriously ill, poor urine flow (< 1 ml/kg/hr), mass, increased creatinine (eGFR < 80), treatment failure, non-E. coli) **OR**
- RUS shows: hydronephrosis (pelvocaliectasis), renal parenchymal loss, kidney size discrepancies

DMSA Scan in 12 months after UTI if:

- Renal ultrasound shows evidence for renal parenchymal loss or kidney size discrepancies

!

Antibiotic
prophylaxis not
recommended for
Gr I-III vesicoureteral reflux

!

Give antibiotic
prophylaxis prior
to VCUG if VCUG
is indicated

Age Categories: Infants

Infants (birth to 60 days of age)

- Infants are traditionally managed by a "rule out sepsis" guideline.
- *The evidence is strongest that febrile infants 0 to 28 days of age are likely to have a serious bacterial infection, with the standard of care being hospital admission, multiple studies, and IV antibiotics. In general, studies suggest that 'low-risk' criteria for older infants are not good predictors of serious bacterial infection in this age group. Clinical practice varies for children age 29 to 60 days with workup and therapy for well-appearing infants as described in Admission and Discharge Criteria section.*



Age Categories: Non-Toilet Trained Children

Non-toilet trained children (greater than 60 days of age)

- This age category usually includes children up to age 2 or 3. The committee chose not to specify an age cutoff feeling that developmental state was more important than age when categorizing patients with UTI. In addition to not being toilet trained, these children are presumed not able to express themselves well enough to localize symptoms.



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Age Categories: Toilet Trained Children

Toilet trained children

- *This age category includes pre-adolescents (up to age 12 years). The committee chose not to specify an age cutoff feeling that developmental state was more important than age when categorizing patients with UTI. This group in some guidelines (NICE, 2007) has been explicitly meant to represent patients older than 2 or 3 that can describe and localize symptoms.*



Age Categories: Adolescents

Adolescents (13 years and older or sexually active)

- Sexually active patients are at risk for presenting with symptoms suggestive of urinary tract infection, which may be due to a urinary tract infection, or to other causes that mimic these symptoms (such as sexually transmitted diseases).



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Defining Atypical vs. Typical UTI

An **atypical UTI** is defined as a UTI with one of the following properties:

- Seriously ill
- Poor urine flow [Committee interpretation: oliguria not due to dehydration, or urinary retention; urine output less than 1 ml / kg / hour]
- Abdominal or bladder mass
- Elevated creatinine (eGFR < 80 ml / min / 1.73 m²)
- Septicemia
- Failure to respond to treatment with suitable antibiotics within 48 hours [Committee interpretation: Treatment failure or persistent bacteremia]
- Infection caused by organism other than *Escherichia coli*

A **typical UTI** is defined as a UTI without any of these conditions.



Defining Atypical vs. Typical UTI: Rationale

- *This categorization of typical vs. atypical UTI is based on a descriptive study of 180 infants aged 1 to 24 months with acute pyelonephritis (Jantunen, 2001). This study found that risk factors for significant urinary tract abnormalities included: younger infants (1 to 6 months of age), urine infected with organisms other than *Escherichia coli*, infants with a positive blood culture, or a lack of *papG* adhesin genes in patients infected with *Escherichia coli*. The other findings appear to have been generated by NICE committee consensus as representing risk factors where further imaging would be warranted.*

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Presumed vs. Definite UTI

Presumed vs. definite UTI (GRADE: B)

- **Presumed** urinary tract infection:
 - In infants and non-toilet trained children, a presumed UTI is defined by a combination of clinical features where urinary tract infection is deemed likely, *regardless of urinalysis result.*
 - In toilet trained children and adolescents, a presumed UTI is defined by a combination of clinical features *and a positive urine screening test* (urinalysis shows nitrite or leukocyte esterase; microscopy shows bacteria or > 10 WBC/ hpf).
- A **Definite** urinary tract infection is defined by a combination of clinical features and a positive urine culture.



Presumed UTI

- *The distinction for infant and non-toilet trained children is based upon the observation that urine screening studies (urinalysis, urine dip and microscopy) in these age groups are felt to be insufficient to rule in or rule out urinary tract infection. (Wong, Lee & Han 2008) (Nys et al. 2006) (Antwi et al. 2008) (McIsaac, Moineddin & Ross 2007) (Little et al. 2006)*
- As a result, the committee felt that these tests were insufficient to rule out urinary tract infection in this age group where clinical suspicion was otherwise high.
- *The strongest clinical predictors of UTI in infants and non-toilet trained children are: Fever (>38 infants) Fever (>39 in non-toilet trained children), Fever > 24 hrs, Fever without apparent source, ill-appearance, abdominal pain and suprapubic tenderness. (Cincinnati 2006, Texas 2008, NICE 2007, Todd 1995, Shaikh 2006)*



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Diagnosis: Definite UTI

Culture results defining a definite UTI are:

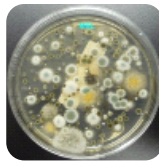
- Single predominant organism (one organism meets criteria below, all other organisms do not meet criteria below) (GRADE: C)
 - $\geq 10^5$ colony forming units (cfu) / ml for clean catch
 - $> 10^4$ cfu/ml for in and out catheterization
 - $> 10^3$ cfu/ml for suprapubic aspiration



Diagnosis: Definite UTI

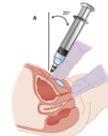
Culture results for definite UTI

- The cutoffs for clean catch are consistent between multiple published guidelines. The cutoffs for cath specimens use cutoffs from 1,000 to 50,000 cfus; but the SCH lab does not report cutoffs of 50,000 and the cutoff of 10,000 is considered fairly equivalent.
- The cutoff for suprapubic aspiration has been anywhere from "any bacteria" to 1,000; however, 1,000 is the minimum concentration currently detectable at our lab.



Diagnosis: Suprapubic Aspiration

- For febrile uncircumcised infant boys, performing a suprapubic aspiration (SPA), with use of local anesthetic (e.g., J-tip) before starting antibiotics should be offered to parents and performed if all of the following criteria are met:
 - 1) Cath screening tests (urinalysis, microscopy) are (+)
 - 2) Provider with demonstrated competency available (may consult Urology, Nephrology, or Neonatology for teaching)
 - 3) Ultrasound guidance available
 - 4) With agreement of family after discussion of risks/benefits
- The rationale for this is that U/As may be falsely (+) in uncircumcised infant boys, therefore, performing an SPA may lead to decreased hospitalization (2 days vs. 5-7 days), decreased resource utilization for imaging, and correct diagnosis that there is no UTI.



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Diagnosis: Adolescent and Sexually Active Patients

- In adolescents and sexually active pre-adolescents, clinicians must document a sexual history and an external genitourinary examination. Clinicians should perform a bimanual examination in females if clinically indicated (e.g., in cases of pelvic pain). (GRADE: C)
- *One ED study of adolescents 12 to 25 years of age presenting with urinary complaints found that 49% of sexually active patients were not tested (Musacchio, Gehani & Garofalo 2009). Of those tested, 12/43 had Chlamydia or gonorrhea, and 13/43 had a positive urine culture. Another study of sexually active females aged 14-22 ascertained through teen health centers and emergency rooms ((Huppert et al. 2007) found the prevalence of UTI and sexually transmitted infection (STI) to be 17 and 33%, respectively.*

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Treatment: Starting Therapy for Presumed UTI

Patients with presumed urinary tract infection should be started on empiric antibiotic therapy (GRADE: D)

- *A study of 278 infants aged 2 weeks to 12 months suggested that treatment within 24 hours of development of fever resulted in less renal involvement in the acute phase than treatment starting at day 4 or later; however, there did not appear to be differences in scarring.(Doganis et al. 2007).*
- The committee felt that given the possible progression to complications including bacteremia, because of the potential of clinical improvement with treatment, and because of the potential for loss to follow up if patients are discharged from the emergency department, that starting empiric therapy immediately is most prudent.

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Treatment: Antibiotic Stewardship

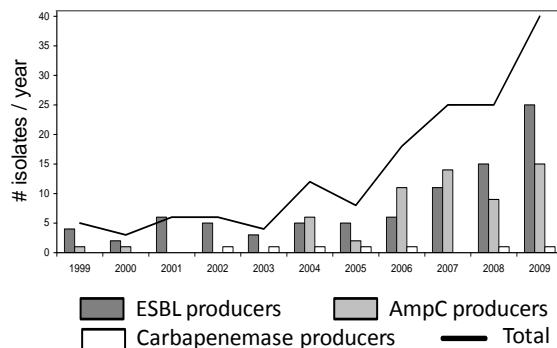
- The emergence of *E. coli* and other Gram-negatives resistant to third-generation cephalosporins that we are seeing in Seattle, around the country, and around the globe, is due to overuse of broad-spectrum antibiotics.
- *Collateral damage*. The intestinal flora constitute an 'organ' unto themselves, and broad-spectrum antibiotics perturb the physiology of this organ, by abolishing antibiotic-susceptible healthy flora and allowing for replacement with antibiotic-resistant strains that are more likely pathogenic.
 - **At the patient level:** this effect is probably most critical for patients who have an above-baseline risk of developing a subsequent infection that arises from their own intestinal reservoir (e.g., urological abnormalities, peritoneal dialysis, central venous catheters, chemotherapy/neutropenia).
 - **At the community level:** reducing susceptible bacteria in any individual's flora may ultimately have effects on others' flora as well, by creating 'super-shedder' individuals that serve to transmit resistant strains to direct contacts in the home and at work.



Treatment: Antibiotic Stewardship

- In 1999, Hoberman et al. published the landmark study supporting empiric use of oral cefixime in uncomplicated pediatric UTI.
- Starting in ~ 2000, resistance to 3rd generation cephalosporins (CS3) agents began to rise around the world, driven by emergence and spread of an *E. coli* strain known as **ST131**, an extended spectrum beta-lactamase producer.
- In 2010-2011, **ST131** was the predominant *E. coli* strain in Seattle.
- Thus, current epidemiology differs dramatically from that during the Hoberman study (conducted 1992-1997), and highlights the perils of routinely using broad-spectrum antibiotics for empiric treatment of infections that are frequently susceptible to narrow-spectrum agents.

Resistance to CS3s among *Enterobacteriaceae* at Seattle Children's Hospital, 1999-2009



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Treatment: Empiric Antibiotic Choice

- Due to concerns about emerging antibiotic resistance in the community, 3rd generation cephalosporins such as oral cefixime are not recommended as first-line empiric outpatient antibiotic therapy.
 - ~80% of first-time UTIs are due to *E. coli*
 - Where cephalosporin allergy is not a concern, a narrow spectrum (1st generation) cephalosporin such as cephalexin is recommended. Alternatively, cefuroxime (2nd generation) also serves as a reasonable option.
 - Note: cephalosporins should not be used where enterococci are suspected, due to intrinsic resistance.
 - In case of cephalosporin allergy, trimethoprim/sulfamethoxazole is an alternative.
- Antibiotic therapy should always be targeted to the sensitivities of the organism when those sensitivities are known.



Treatment: Empiric Antibiotic Choice

- Further rationale for recommending empiric cephalexin therapy included factors such as cost and percent of antibiotic excreted unchanged in the urine.

	Cephalexin (Keflex)	Cefuroxime (Ceftin)	Cefixime (Suprax)
Approximate Daily Dosing	50mg/kg/day (divided BID-QID)	30mg/kg/day (divided BID)	Day 1: 16mg/kg/day Subsequent days: 8mg/kg/day
Cost (suspension)	250mg/5ml (100ml)= \$18.90 or \$0.189/ml	250mg/5ml (100ml)= \$151.74 or \$1.52/ml	100mg/5ml (50ml)= \$154.88 or \$3.10/ml
Cost/day for a 10 kg patient:	10 ml x \$0.189= \$1.89	6 ml x \$1.52/ml= \$9.12	8ml x \$3.10/ml= \$24.80 (day 1) 4ml x \$3.10/ml= \$12.40 (subsequent)
% excreted unchanged in urine	90%	50%	50%



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Treatment: "Switch Therapy" (IV to Oral Antibiotics)

- *Strong evidence supported the equivalence of long-course IV therapy, "switch" therapy of 2-4 days of IV therapy followed by PO therapy, and PO therapy alone. (Pohl (2008) Hodson (2009), Montini (2007)). However, most studies did not enroll patients starting at birth, therefore, early switch therapy may not be appropriate for patients 0-30 days of age.*
- Given the high incidence of bacteremia (12.4%) and potential for suboptimal blood culture volumes in infants, the committee recommended 7 days of IV therapy followed by 7 days of oral therapy for this age group.
- Given this relatively short course of IV antibiotics, Peripherally Inserted Central Catheters (PICCs) are **not** necessary.

Treatment: UTI With Positive Blood Cultures

- Due to the lack of studies on bacteremia associated with UTI; the recommendation for a minimum of 7 days of IV antibiotics for patients with positive blood cultures is based on local consensus. Further, this recommendation is extrapolated from known outcomes of other systemic infections (solid organ infections, central line infections, serious gram (-) infections). Due to the additional factor of an immature immune system, a minimum of 10 days of IV antibiotics is recommended for neonates

Treatment: Cystitis

- Adolescent females with presumed cystitis can be treated with 3-day course of narrow-spectrum antibiotic (e.g. cephalexin or trimethoprim-sulfamethoxazole).
- *A systematic review conducted to examine the appropriate treatment of cystitis concluded that in children 3 months to 18 years of age, that a 2-4 day course of systemic antibiotics appeared as effective as a 7-14 day course of systemic antibiotics in eradicating lower tract UTI in children (Michael, 2009), however, it was noted that this analysis pooled many small studies with wide age ranges. The committee felt that given the difficulty in definitively distinguishing between lower and upper tract UTI in the younger age groups, that this recommendation was most appropriate.*

Treatment: No Clinical Improvement in 48 Hours

- Expect clinical improvement within 48 hours; fever should resolve by 72 hours. In patients that have not clinically improved in 48 hours despite appropriate antibiotic therapy, ensure renal ultrasound has occurred and consider specialty consult. (GRADE: D)
- If the patient is persistently febrile: Consider abdomen/pelvis CT with and without IV contrast. CT should be considered since RUS does not reliably detect perinephric abscesses. (GRADE: D)

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Treatment: Follow-up Cultures

Follow-up urine cultures for test of cure are not routinely indicated. (GRADE: B)

- *Two retrospective reviews support the lack of usefulness of follow-up urine cultures at 48 hours. One study of 364 children < 18 years of age showed that of 291 follow-up urine cultures, none were positive (Currie, 2003). Another study of 599 children hospitalized and treated with UTI with 328 having a urine culture at 48 hours found only one positive culture (Oreskovic, 2007).*

Diagnostic Imaging: Renal Ultrasound (RUS)

Renal ultrasounds are used to screen for upper tract anatomic abnormalities but may miss reflux or renal scarring. Its diagnostic capabilities are:

- 1) Excellent assessment of renal anatomy, including presence, size, position, and whether there is hydronephrosis.
- 2) Ureterectasis and collecting system duplication.
- 3) Bladder volume can be estimated, and the bladder can also be assessed for wall thickening, distention, ureteroceles, debris, and posterior-urethral dilatation in boys.
- 4) About 40% of acute pyelonephritis can be identified, and up to 60-80% if power Doppler ultrasound is used, but this is not a primary indication for ultrasound.
- 5) Renal masses, stones, or renal parenchymal abscesses can be detected; but perinephric abscesses cannot be reliably detected.



Diagnostic Imaging: Renal Ultrasound (RUS)

- *It is felt that a RUS is high yield by certain guidelines (Cincinnati, 2006, AAP, 1999, NICE guideline) in children up to 36 months of age. Since the committee was most concerned with identifying anatomical abnormalities and based on experience with detecting partial posterior urethral valves in older boys, the committee adopted this strategy.*
- *Two studies suggested that third-trimester prenatal ultrasounds were highly likely to identify the anatomical abnormalities on postnatal ultrasound. (Miron et al. 2007, Calisti et al. 2005). It was decided that if the prenatal ultrasound images could be reviewed by radiology, and that they could determine if the quality was sufficient that a normal prenatal ultrasound could preclude obtaining a repeat ultrasound at the time of infection.*



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Diagnostic Imaging: Voiding Cystourethrogram (VCUG)

The diagnostic capabilities of VCUG are:

- 1) It is the definitive test for vesicoureteral reflux (VUR).
- 2) This test delineates lower tract (bladder and urethral anatomy), and also shows the collecting systems and ureters if VUR is present.
- 3) The precise relationship between VUR and acute pyelonephritis is not fully understood, as up to 60% of patients with acute pyelonephritis may not have VUR.
- 4) VCUG is not a good study for detection of acute pyelonephritis or to delineate renal parenchymal anatomy.



Diagnostic Imaging: Voiding Cystourethrogram (VCUG)

Although VCUG is felt to be the best imaging study for detection of VUR, it is no longer necessary for most patients

- *Approximate prevalences of VUR among girls age 0 to 18 yrs are: (Grade I: 7%; Grade II: 22%; Grade III: 6%; Grade IV: 1%; Grade V: < 1%). Antibiotic prophylaxis is not felt to be helpful for patients with no reflux or grade I-III reflux (Cincinnati 2006, Chand 2003)*
- This suggests that over 30 VCUGs would need to be performed to find a patient with high grade (IV-V) reflux.

Diagnostic Imaging: Radionuclide VCUG

OPTION: Radionuclide VCUG may be used in place of fluoroscopic VCUG for initial detection of VUR in females. This study offers a lower radiation dose, although with lesser anatomic detail and limited spatial resolution.

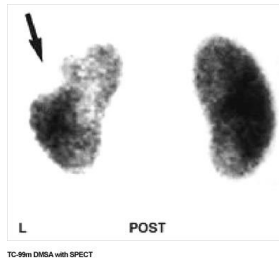
[To DMSA Scan](#)

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Diagnostic Imaging: Renal Dimercaptosuccinic Acid (DMSA) Scan

- In order to evaluate for renal scarring, a DMSA scan should be ordered 12 months after a UTI in the following exceptional circumstances:
 - In all age groups if renal ultrasound shows evidence for renal parenchymal loss or kidney size discrepancies
 - In children 6 months of age and younger with atypical infections
- A DMSA scan is also considered the gold standard for the detection of acute pyelonephritis, as there is a 97% agreement between the scan and histopathologic findings. Therefore, a DMSA can also be used to confirm pyelonephritis in cases where the diagnosis is in question.



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Diagnostic Imaging: Antibiotic Prophylaxis Prior to VCUG

When a VCUG is indicated, clinicians should prescribe antibiotic prophylaxis for patients until VCUG is performed. This is consistent with multiple published guidelines (Cincinnati, 2006), (AAP, 1999), (Seattle, 1999).

- Infants <2 months: amoxicillin 20 mg/kg, up to 500 mg once daily
- Infants >2 months to children <18 years: trimethoprim-sulfamethoxazole 2 mg/kg of trimethoprim up to 80 mg once daily OR nitrofurantoin 1 mg/kg up to 100 mg once daily

Antibiotic Prophylaxis if VUR is Found

Ongoing antibiotic prophylaxis is not recommended for patients with first febrile urinary tract infection, or with low grade (I-III) vesicoureteral reflux (VUR). Multiple randomized trials examined the relationship between the effectiveness of antibiotic prophylaxis in different patient populations. (GRADE: A)



Antibiotic Prophylaxis if VUR is Found

Summaries of literature evidence

- *A trial of 338 randomized children with first febrile UTI showed no benefit of prophylaxis (Montini et al. 2008).*
- *A trial of 100 randomized patients showed no benefit in children under 30 months with grade II-IV reflux (Pennesi et al. 2008).*
- *A study of 225 randomized patients 1 month to 3 years of age with Grade I-III reflux showed no benefit of prophylaxis. (Roussey-Kesler et al. 2008).*
- *An retrospective review suggested that recurrent UTIs were associated with high-grade (IV, V) reflux, Caucasian race, and ages 3-5; and that antibiotic prophylaxis was associated with increasing resistance of organisms. (Conway et al. 2007).*
- *Another prospective randomized study of 218 children aged 3 months to 18 years of age suggests that grade I-III reflux does not increase the incidence of UTI / pyelonephritis, and that antibiotic prophylaxis does not appear to prevent the recurrence of UTI nor the development of renal scarring. (Garin et al. 2006).*



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Executive Summary

Objective

- Create an evidence-based clinical guideline related to aspects of diagnosis, management and follow-up for patients aged birth to 18 years with first-time presumed or definite UTI and no significant co-morbid conditions.

New or Updated Recommendations

- **Diagnosis:**
 - Diagnose non-toilet trained children via high quality specimen (not a bag).
 - In adolescents, document the external GU exam and test for GC/Chlamydia.
- **Empiric Therapy:**
 - Start empiric therapy with clinical suspicion of UTI in non-toilet trained children and with clinical findings plus positive urinalysis/urine dip or microscopy in toilet-trained children. *Therapy should always be targeted to sensitivities once available.*
 - Admitted children 31 days and older:
 - Start on IV ceftriaxone, or IV ampicillin + gentamicin if Enterococcus suspected.
 - Infants 31-60 days of age not meeting admission criteria:
 - Receive IM ceftriaxone.
 - Outpatient:
 - PO cefuroxime or cephalexin or PO trimethoprim-sulfamethoxazole if cephalosporin allergy, or IM ceftriaxone.
- **Treatment Duration:**
 - Infants 0-30 days:
 - 7 days IV followed by 7 days PO
 - Infants 31-60 days:
 - IV until afebrile x 24 hours and blood cultures negative x 36 hours, then PO to complete 14 day course
 - Adolescents with cystitis:
 - PO therapy for 3 days
- **Imaging:**
 - Overall reduction of VCUGs for initial imaging in patients with first-time UTI.
 - Infants and Non-toilet trained children:
 - Renal ultrasound or high quality third trimester ultrasound read as normal (VCUG only if atypical UTI (see guideline for definition)).
 - Infants up to 6 months of age with atypical UTI:
 - DMSA scan 12 months after infection.
 - Toilet trained children and adolescents:
 - Renal ultrasound for boys with first UTI and girls with atypical UTI.

Evidence

- A SCH Librarian performed a broad literature search and found a recent comprehensive UTI guideline (NICE 2007) that reviewed the literature through 2006. All new evidence from 2006 to present, and additional evidence related to utility of prenatal ultrasounds, was reviewed by a multidisciplinary committee using the Clinical Effectiveness Program's systematic process. A total of 93 articles were referenced to create the final guideline.

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Self-Assessment

- If you are taking this self-assessment as a part of required departmental training, you will need to logon to the [Learning Center](#) to receive credit. Completion also qualifies you for 1 hour of Category II CME credit.

- 1) Which of the following is NOT an exclusion criterion?
 - a) Chronic kidney disease (decreased GFR)
 - b) Sepsis/ Meningitis
 - c) Neurogenic bladder/ obstructive uropathy
 - d) Known Grade IV-V reflux
 - e) Circumcision
 - f) 2nd episode of pyelonephritis
- 2) Which of the following statements is/are TRUE about sexually active adolescents?
 - a) Symptoms of UTI mimic those of STI
 - b) The prevalence of UTI and STI are 17% and 33% respectively
 - c) A sexual history and a bimanual exam (if pelvic pain is present) should be done
 - d) All of the above
- 3) Which of the following statements is/are TRUE regarding admission criteria?
 - a) All infants < 30 days of age with presumed or definite UTI should be admitted
 - b) Only infants < 30 days of age who are febrile should be admitted
 - c) Admit all febrile patients 31-60 days of age with presumed or definite UTI
 - d) a and c
- 4) Patients with presumed urinary tract infection do not need empiric treatment, treatment should only be started if the urine culture is (+)
 - a) TRUE
 - b) FALSE
- 5) Which of the following is/are TRUE regarding empiric antibiotic therapy?
 - a) Cefixime is the only choice that is acceptable for outpatient therapy
 - b) The majority of infections are caused by e. coli, most of which are susceptible to 1st and 2nd generation cephalosporins
 - c) There is no need to tailor antibiotics once the sensitivities are known
 - d) If gram (+) cocci are primarily identified on urine culture, cephalosporins are not indicated as empiric therapy due to the intrinsic resistance of enterococci to cephalosporins
 - e) a and c are correct
 - f) b and d are correct
- 6) Given the high incidence of bacteremia (12.4%) and potential for suboptimal blood culture volumes in infants, the committee recommended 7 days of IV therapy followed by 7 days of oral therapy for infants < 30 days of age with pyelonephritis
 - a) True
 - b) False
- 7) Which of the following statements is TRUE regarding renal ultrasounds?
 - a) They evaluate the lower tract (bladder and urethra) well
 - b) They are able to reliably detect the presence of a perinephric abscess
 - c) They are indicated for all toilet trained or adolescent girls with UTI
 - d) They are indicated for all infants and non-toilet trained children with pyelonephritis
- 8) Which of the following statements is/are FALSE regarding VCUGs?
 - a) It provides detailed images of the upper urinary tract
 - b) It is the definitive test for VUR
 - c) Most reflux is grade IV or higher, therefore VCUGs are always indicated
 - d) Studies have shown that there is no advantage to antibiotic prophylaxis in patients with Grades I-III reflux
 - e) a and c
 - f) b and d
- 9) Which of the following statement is/are TRUE regarding DMSA scans?
 - a) A DMSA scan is considered the gold standard for detecting pyelonephritis and renal scarring
 - b) Are indicated 12 months after a UTI for all age groups if renal ultrasound shows evidence for renal parenchymal loss or kidney size discrepancies
 - c) Are indicated 12 months after a UTI in children 6 months of age and younger with atypical infections
 - d) a, b and c
 - e) Only b and c
- 10) Which of the following statement is/are TRUE regarding antibiotic stewardship?
 - a) Infections should be treated with the narrowest-spectrum antibiotic possible
 - b) The number of isolates of extended spectrum beta-lactamase (ESBL) producing E coli is increasing
 - c) The use of broad spectrum antibiotics selects for resistant organisms in the intestinal flora.
 - d) All of the above

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[View Answers](#)

Answer Key

Answer Key

- 1) The correct answer is (e); all other choices except circumcision are exclusion criteria
- 2) The correct answer is (d); all of the above statements are true about sexually active adolescents
- 3) The correct answer is (d); both infants <30 days with presumed or definite UTI AND all febrile patients 31-60 days of age with presumed or definite UTI should be admitted to the hospital
- 4) The correct answer is (b); patients with presumed UTI should receive empiric antibiotic treatment.
- 5) The correct answer is (f) it is true that the majority of infections are caused by e. coli, most of which are susceptible to 1st and 2nd generation cephalosporins. It is also true that if gram (+) cocci are primarily identified on urine culture, cephalosporins are not indicated as empiric therapy due to the intrinsic resistance of enterococci to cephalosporins
- 6) The correct answer is (a); 7 days of IV therapy followed by 7 days of oral therapy for infants < 30 days of age with pyelonephritis is recommended
- 7) The correct answer is (d); renal ultrasounds are indicated for all infants and non-toilet trained children with pyelonephritis, the remainder of the statements are false.
- 8) The correct answer is (e); VCUGs do not provide detailed images of the upper urinary tract. Most reflux is grade I – III, not grade IV or higher.
- 9) The correct answer is (d), all three statements about DMSA scans are true.
- 10) The correct answer is (d) all three statements about antibiotic stewardship are true.

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Evidence Ratings

We used the GRADE method of rating evidence quality. Evidence is first assessed as to whether it is from randomized trials, or observational studies. The rating is then adjusted in the following manner:

Quality ratings are downgraded if studies

- have serious limitations
- have inconsistent results
- if evidence does not directly address clinical questions
- if estimates are imprecise OR
- if it is felt that there is substantial publication bias

Quality ratings can be upgraded if it is felt that

- the effect size is large
- if studies are designed in a way that confounding would likely underreport the magnitude of the effect OR
- if a dose-response gradient is evident

The quality of evidence is as follows:

High quality	A or ⊕⊕⊕⊕
Moderate quality	B or ⊕⊕⊕○
Low quality	C or ⊕⊕○○
Very low quality	D or ⊕○○○

This will appear in the text as: GRADE: A.

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Summary of Version Changes

Version 2 (12/03/2011): Expanded recommendation for empiric outpatient antibiotics to include oral cephalexin or oral cefuroxime

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Bibliography

1. AAP, 1999. AAP Committee on Quality Improvement, Subcommittee on Urinary Tract Infection. Practice Parameter: The Diagnosis, Treatment, and Evaluation of the Initial Urinary Tract Infection in Febrile Infants and Young Children. *Pediatrics*. 1999; 103: 843-852.
2. AAP, 2006. Committee on Infectious Diseases. The Use of Systemic Fluoroquinolones. *Pediatrics*. 2006; 118: 1287-1292.
3. Agras, K., Ortapamuk, H., Naldoken, S., Tuncel, A. & Atan, A. 2007, "Resolution of cortical lesions on serial renal scans in children with acute pyelonephritis.", *Pediatric radiology*, vol. 37, no. 2, pp. 153-158.
4. Anonymous, 2009. Urinary tract infections and related conditions: levels of scientific evidence for specific therapies. Accessed at: www.naturalstandard.com on September 9, 2009.
5. Antwi, S., Bates, I., Baffoe-Bonnie, B. & Critchley, J. 2008, "Urine dipstick as a screening test for urinary tract infection.", *Annals of Tropical Paediatrics*, vol. 28, no. 2, pp. 117-122.
6. Austin BJ, Bollard C, Gunn TR. 1999, Is urethral catheterization a successful alternative to suprapubic aspiration in neonates? *J Paediatr Child Health* 1999;35:34-6.
7. Baker MD, Bell LM, Avner JR. 1993, Outpatient management without antibiotics of fever in selected infants. *N Engl J Med*. 1993;329:1437-41.
8. Baskin MN, O'Rourke EJ, Fleisher GR. 1992, Outpatient treatment of febrile infants 28 to 89 days of age with intramuscular administration of ceftriaxone. *J Pediatr*. 1992;120:22-7.
9. BMJ, 2010. Accessed at <http://clinicalevidence.bmj.com/ceweb/conditions/chd/0306/0306.jsp> on April 12, 2010.
10. Bonsu, B.K. & Harper, M.B. 2007, "Leukocyte counts in urine reflect the risk of concomitant sepsis in bacteriuric infants: a retrospective cohort study.", *BMC Pediatrics*, vol. 7, pp. 24.
11. Branson BM, Handsfield HH, Lampe MA, et al. 2006, Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep*. 2006;55(RR-14):1-17.
12. Brown JC, Burns JL, Cummings P. Ampicillin Use in Infant Fever: A Systematic Review. *Arch Pediatr Adolesc Med*. 2002; 156: 27-32.
13. Calisti, A., Perrotta, M.L., Oriolo, L., Ingianna, D. & Sciortino, R. 2005, "Diagnostic workup of urinary tract infections within the first 24 months of life, in the era of prenatal diagnosis. The contribution of different imaging techniques to clinical management.", *Minerva pediatrica*, vol. 57, no. 5, pp. 269-273.
14. Chen, L. & Baker, M.D. 2006, "Racial and ethnic differences in the rates of urinary tract infections in febrile infants in the emergency department.", *Pediatric emergency care*, vol. 22, no. 7, pp. 485-487.
15. Cincinnati, 2006. UTI Guideline Team, Cincinnati Children's Hospital Medical Center: Evidence-based care guideline for medical management of first urinary tract infection in children 12 years of age or less. <http://www.cincinnatichildrens.org/assets/0/78/1067/2709/2777/2793/9199/c2dda8f2f122-4cc4-9385-f02035d4f322.pdf>. Guideline 7, pages 1-23, November, 2006.
16. Claret Teruel, G., Garcia Garcia, J.J., Fernandez de Sevilla Estrach, M., Corrales Magin, E., Trenchs Sainz de la Maza, V., Rodriguez Araez, A., Camacho Diaz, J.A. & Luaces Cubells, C. 2008, "Oral therapy for urinary tract infections in infants aged 3 to 12 months.", *European Journal of Clinical Microbiology & Infectious Diseases*, vol. 27, no. 9, pp. 887-889.
17. Conway, P.H., Cnaan, A., Zaoutis, T., Henry, B.V., Grundmeier, R.W. & Keren, R. 2007, "Recurrent urinary tract infections in children: risk factors and association with prophylactic antimicrobials", *JAMA*, vol. 298, no. 2, pp. 179-186.
18. Craig JC, Simpson JM, Williams GJ, et al. 2009, Antibiotic Prophylaxis and Recurrent Urinary Tract Infection in Children. *N Engl J Med*. 2009; 361: 1748-59.
19. Currie ML, Mitz L, Raasch CS, Greenbaum LA. 2003, Follow-up urine cultures and fever in children with urinary tract infection. *Arch Pediatr Adolesc Med*. 2003 Dec;157(12):1237-40.
20. Defoor, W., Ferguson, D., Mashni, S., Creelman, L., Reeves, D., Minevich, E., Reddy, P. & Sheldon, C. 2006, "Safety of gentamicin bladder irrigations in complex urological cases.", *Journal of Urology*, vol. 175, no. 5, pp. 1861-1864.
21. Doganis, D., Siafas, K., Mavrikou, M., Issaris, G., Martirosova, A., Perperidis, G., Konstantopoulos, A. & Sinaniotis, K. 2007, "Does early treatment of urinary tract infection prevent renal damage?[see comment].", *Pediatrics*, vol. 120, no. 4, pp. e922-8.
22. Downs SM. 1999, Technical Report: Urinary Tract Infections in Febrile Infants and Young Children. *Pediatrics*. 1999; 103: e54.
23. Drew JH, Acton CM. 1976, Radiological findings in newborn infants with urinary infection. *Arch Dis Child*. 1976; 51: 628-30.
24. EAU 2009. Grabe M, Bishop MC, Bjerklund-Johansen TE, et al. Urinary tract infections in children. In: *Guidelines on Urological Infections*. European Association of Urology. 2009.
25. Eliopoulou, M., Georgakopoulos, C. & Beratis, N. 2007, "beta-Glucuronidase activity in cerebrospinal fluid pleocytosis due to urinary tract infection.", *Acta Paediatrica*, vol. 96, no. 7, pp. 1053-1058.
26. Fallahzadeh, M.H. & Ghane, F. 2006, "Urinary tract infection in infants and children with diarrhoea.", *Eastern Mediterranean Health Journal*, vol. 12, no. 5, pp. 690-694.
27. Faust, W.C., Diaz, M. & Pohl, H.G. 2009, "Incidence of post-pyelonephritic renal scarring: a meta-analysis of the dimercapto-succinic acid literature.", *Journal of Urology*, vol. 181, no. 1, pp. 290-297.
28. Freedman AL. 2005, Urologic diseases in North America Project: trends in resource utilization for urinary tract infections in children. *J Urol*. 2005;173:949-54. (from abstract)

Bibliography

29. Galanakis, E., Bitsori, M., Dimitriou, H., Giannakopoulou, C., Karkavitsas, N.S. & Kalmanti, M. 2007, "Serum and urine interleukin-6 and transforming growth factor-beta1 in young infants with pyelonephritis.", *International Urology & Nephrology*, vol. 39, no. 2, pp. 581-585.
30. Garin, E.H., Olavarria, F., Garcia Nieto, V., Valenciano, B., Campos, A. & Young, L. 2006, "Clinical significance of primary vesicoureteral reflux and urinary antibiotic prophylaxis after acute pyelonephritis: a multicenter, randomized, controlled study", *Pediatrics*, vol. 117, no. 3, pp. 626-632.
31. Gassler, N., Paul, H. & Runge, M. 2006, "Rapid detection of urinary tract infection—evaluation of flow cytometry.", *Clinical nephrology*, vol. 66, no. 5, pp. 331-335.
32. Ghaemi, S., Fesharaki, R.J. & Kelishadi, R. 2007, "Late onset jaundice and urinary tract infection in neonates.", *Indian journal of pediatrics*, vol. 74, no. 2, pp. 139-141.
33. Guay, D.R. 2009, "Cranberry and urinary tract infections", *Drugs*, vol. 69, no. 7, pp. 775-807.
34. Guyatt GH, Oxman AD, Kunz R, et al. 2008, GRADE: going from evidence to recommendations. *BMJ*. 2008; 336: 1049-105.
35. Guven, A.G., Kazdal, H.Z., Koyun, M., Aydn, F., Gungor, F., Akman, S. & Baysal, Y.E. 2006, "Accurate diagnosis of acute pyelonephritis: How helpful is procalcitonin?.", *Nuclear medicine communications*, vol. 27, no. 9, pp. 715-721.
36. Hewitt, I.K., Tomasi, L., Pavanello, L., Maschio, F., Molinari, P.P., Toffolo, A., Crivellaro, C., Zucchetto, P., Zacchello, G. & Montini, G. 2006, "Early treatment of acute pyelonephritis in children fails to reduce renal scarring [abstract no: SA-PO1100]", *Journal of the American Society of Nephrology*, vol. 17, no. Abstracts, pp. 804A.
37. Hewitt, I.K., Zucchetto, P., Rigon, L., Maschio, F., Molinari, P.P., Tomasi, L., Toffolo, A., Pavanello, L., Crivellaro, C., Bellato, S. & Montini, G. 2008, "Early treatment of acute pyelonephritis in children fails to reduce renal scarring: data from the Italian Renal Infection Study Trials", *Pediatrics*, vol. 122, no. 3, pp. 486-490.
38. Hodson EM, Willis NS, Craig JC. Antibiotics for acute pyelonephritis in children. *The Cochrane Database of Systematic Reviews*. 2009; 3.
39. Huang, D.T., Huang, F.Y., Tsai, T.C., Tsai, J.D., Chiu, N.C. & Lin, C.C. 2007, "Clinical differentiation of acute pyelonephritis from lower urinary tract infection in children.", *Journal of Microbiology, Immunology & Infection*, vol. 40, no. 6, pp. 513-517.
40. Huppert, J.S., Biro, F., Lan, D., Mortensen, J.E., Reed, J. & Slap, G.B. 2007, "Urinary symptoms in adolescent females: STI or UTI?.", *Journal of Adolescent Health*, vol. 40, no. 5, pp. 418-424.
41. Jantunen ME, Siitonen A, Ala-Houhala M, et al. 2001, Predictive factors associated with significant urinary tract abnormalities in infants with pyelonephritis. *Pediatric Infectious Disease Journal*. 2001; 20: 597-601.
42. Jepson RG, Mihaljevic L, Craig JC. 2009, Cranberries for treating urinary tract infections. *Cochrane Database of Systematic Reviews*, 2009.
43. Jaskiewicz JA, McCarthy CA, Richardson AC, et al. 1994, Febrile infants at low risk for serious bacterial infection—an appraisal of the Rochester criteria and implications for management. Febrile Infant Collaborative Study Group. *Pediatrics*. 1994;94:390-6.
44. Keren R, Chan E. 2002, A Meta-analysis of Randomized, Controlled Trials Comparing Short- and Long-Course Antibiotic Therapy for Urinary Tract Infections in Children. *Pediatrics*. 2002; 109: e70.
45. Kotoula, A., Gardikis, S., Tsalkidis, A., Mantadakis, E., Zissimopoulos, A., Deftereos, S., Tripsianis, G., Manolas, K., Chatzimichael, A. & Vaos, G. 2009, "Comparative efficacies of procalcitonin and conventional inflammatory markers for prediction of renal parenchymal inflammation in pediatric first urinary tract infection.", *Urology*, vol. 73, no. 4, pp. 782-786.
46. Kozer, E., Rosenbloom, E., Goldman, D., Lavy, G., Rosenfeld, N. & Goldman, M. 2006, "Pain in infants who are younger than 2 months during suprapubic aspiration and transurethral bladder catheterization: a randomized, controlled study.", *Pediatrics*, vol. 118, no. 1, pp. e51-6.
47. Kyriakidou KG, Rafailidis P, Matthaïou DK, Athanasiou S, Falagas ME. 2008, Short- versus long-course antibiotic therapy for acute pyelonephritis in adolescents and adults: a meta-analysis of randomized controlled trials. *Clin Ther*. 2008; 30:1859-68.
48. Leroy, S., Romanello, C., Galetto-Lacour, A., Smolkin, V., Korczowski, B., Rodrigo, C., Tuerlinckx, D., Gajdos, V., Moulin, F., Contardo, M., Gervaix, A., Halevy, R., Duhl, B., Prat, C., Borgh, T.V., Foix-l'Helias, L., Dubos, F., Gendrel, D., Breart, G. & Chalumeau, M. 2007, "Procalcitonin to reduce the number of unnecessary cystographies in children with a urinary tract infection: a European validation study.", *Journal of Pediatrics*, vol. 150, no. 1, pp. 89-95.
49. Little, P., Turner, S., Rumsby, K., Warner, G., Moore, M., Lowes, J.A., Smith, H., Hawke, C. & Mullee, M. 2006, "Developing clinical rules to predict urinary tract infection in primary care settings: sensitivity and specificity of near patient tests (dipsticks) and clinical scores.", *British Journal of General Practice*, vol. 56, no. 529, pp. 606-612.
50. Magin, E.C., Garcia-Garcia, J.J., Sert, S.Z., Giral, A.G. & Cubells, C.L. 2007, "Efficacy of short-term intravenous antibiotic in neonates with urinary tract infection.", *Pediatric emergency care*, vol. 23, no. 2, pp. 83-86.
51. Mclsaac, W.J., Moineddin, R. & Ross, S. 2007, "Validation of a decision aid to assist physicians in reducing unnecessary antibiotic drug use for acute cystitis.", *Archives of Internal Medicine*, vol. 167, no. 20, pp. 2201-2206.
52. Michael M, Hodson EM, Craig JC, Martin S, Moyer VA. 2009, Short versus standard duration oral antibiotic therapy for acute urinary tract infection in children. *Cochrane Database of Systematic Reviews*. 2009.

Bibliography

53. Mohkam, M., Asgarian, F., Fahimzad, A., Sharifian, M., Dalirani, R. & Abdollah Gorgi, F. 2009, "Diagnostic potential of urinary tumor necrosis factor-alpha in children with acute pyelonephritis.", *Iranian journal of Kidney Diseases*, vol. 3, no. 2, pp. 89-92.
54. Mohkam, M., Karimi, A., Habibian, S. & Sharifian, M. 2008, "Urinary N-acetyl-beta-D-glucosaminidase as a diagnostic marker of acute pyelonephritis in children.", *Iranian journal of Kidney Diseases*, vol. 2, no. 1, pp. 24-28.
55. Montini, G., Rigon, L., Zucchetto, P., Fregonese, F., Toffolo, A., Gobber, D., Cecchin, D., Pavanello, L., Molinari, P.P., Maschio, F., Zanchetta, S., Cassar, W., Casadio, L., Crivellaro, C., Fortunati, P., Corsini, A., Calderan, A., Comacchio, S., Tommasi, L., Hewitt, I.K., Da Dalt, L., Zacchello, G., Dall'Amico, R. & IRIS, G. 2008, "Prophylaxis after first febrile urinary tract infection in children? A multicenter, randomized, controlled, noninferiority trial.", *Pediatrics*, vol. 122, no. 5, pp. 1064-1071.
56. Montini, G., Toffolo, A., Zucchetto, P., Dall'Amico, R., Gobber, D., Calderan, A., Maschio, F., Pavanello, L., Molinari, P.P., Scorrano, D., Zanchetta, S., Cassar, W., Brisotto, P., Corsini, A., Sartori, S., Da Dalt, L., Murer, L. & Zacchello, G. 2007, "Antibiotic treatment for pyelonephritis in children: multicentre randomised controlled non-inferiority trial", *BMJ*, vol. 335, no. 7616, pp. 386.
57. Musacchio, N.S., Gehani, S. & Garofalo, R. 2009, "Emergency department management of adolescents with urinary complaints: missed opportunities.", *Journal of Adolescent Health*, vol. 44, no. 1, pp. 81-83.
58. Naseri, M. 2008, "Alterations of peripheral leukocyte count, erythrocyte sedimentation rate, and C-reactive protein in febrile urinary tract infection.", *Iranian journal of Kidney Diseases*, vol. 2, no. 3, pp. 137-142.
59. NICE, 2007. National Collaborating Centre for Women's and Children's Health. *Urinary tract infection in children: diagnosis, treatment and long-term management*. 2007.
60. Nys, S., van Merode, T., Bartelds, A.I. & Stobberingh, E.E. 2006, "Urinary tract infections in general practice patients: diagnostic tests versus bacteriological culture", *Journal of Antimicrobial Chemotherapy*, vol. 57, no. 5, pp. 955-958.
61. Oreskovic NM, Sembrano EU. 2007, Repeat urine cultures in children who are admitted with urinary tract infections. *Pediatrics*. 2007 Feb;119(2):e325-9.
62. Ottiger, C., Schaer, G. & Huber, A.R. 2007, "Time-course of quantitative urinary leukocytes and bacteria counts during antibiotic therapy in women with symptoms of urinary tract infection.", *Clinica Chimica Acta*, vol. 379, no. 1-2, pp. 36-41.
63. Otukesh, H., Fereshtehnejad, S.M., Hoseini, R., Hekmat, S., Chalian, H., Chalian, M., Bedayat, A., Salman Yazdi, R., Sabaghi, S. & Mahdavi, S. 2009, "Urine macrophage migration inhibitory factor (MIF) in children with urinary tract infection: a possible predictor of acute pyelonephritis.", *Pediatric Nephrology*, vol. 24, no. 1, pp. 105-111.
64. Parvex, P., Willi, J.P., Kossovsky, M.P. & Girardin, E. 2008, "Longitudinal analyses of renal lesions due to acute pyelonephritis in children and their impact on renal growth", *Journal of Urology*, vol. 180, no. 6, pp. 2602-2606.
65. Pashapour, N., Nikbahksh, A.A. & Golmohammadlou, S. 2007, "Urinary tract infection in term neonates with prolonged jaundice.", *Urology Journal*, vol. 4, no. 2, pp. 91-94.
66. Pennesi, M., Travan, L., Peratoner, L., Bordugo, A., Cattaneo, A., Ronfani, L., Minisini, S., Ventura, A. & North East Italy Prophylaxis in VUR study, group 2008, *Pediatrics*, vol. 121, no. 6, pp. e1489-94.
67. Pohl A. 2009, Modes of administration of antibiotics for symptomatic severe urinary tract infections. *Cochrane Database of Systematic Reviews*, 2009.
68. Prais, D., Shoov-Furman, R. & Amir, J. 2009, "Is ritual circumcision a risk factor for neonatal urinary tract infections?.", *Archives of Disease in Childhood*, vol. 94, no. 3, pp. 191-194.
69. Pryles CV, Atkin MD, Morse TS, et al. 1959, Comparative bacteriologic study of urine obtained from children by percutaneous suprapubic aspiration of the bladder and by catheter. *Pediatrics* 1959;24:983-91.
70. Riboldi, P., Gerosa, M. & Meroni, P.L. 2009, "Pidotimod: a reappraisal", *International Journal of Immunopathology & Pharmacology*, vol. 22, no. 2, pp. 255-262.
71. Rodriguez, L.M., Robles, B., Marugan, J.M., Suarez, A. & Santos, F. 2008, "Urinary interleukin-6 is useful in distinguishing between upper and lower urinary tract infections.", *Pediatric Nephrology*, vol. 23, no. 3, pp. 429-433.
72. Roussey-Kesler, G., Gadjos, V., Idres, N., Horen, B., Ichay, L., Leclair, M.D., Raymond, F., Grellier, A., Hazart, I., de Parscau, L., Salomon, R., Champion, G., Leroy, V., Guignon, V., Siret, D., Palcoux, J.B., Taque, S., Lemoigne, A., Nguyen, J.M. & Guyot, C. 2008, "Antibiotic prophylaxis for the prevention of recurrent urinary tract infection in children with low grade vesicoureteral reflux: results from a prospective randomized study", *Journal of Urology*, vol. 179, no. 2, pp. 674-679.
73. Schneider RE. 2004, *Urologic Procedures*. In: Robert JR, Hedges JR. *Clinical Procedures in Emergency Medicine*. 6(3). 4th ed. Philadelphia, PA: W.B. Saunders Co; 2004: 1098-1100.
74. Seattle, 1999. *Seattle Children's Hospital. Guidelines for Management of Urinary Tract Infections*
75. Shaikh N, Morone NE, Lopez J, et al. 2007, Does This Child Have a Urinary Tract Infection? *JAMA*. 2007; 298(24) 2895-2904.
76. Sheu, J.N., Chen, M.C., Chen, S.M., Chen, S.L., Chiou, S.Y. & Lue, K.H. 2009, "Relationship between serum and urine interleukin-6 elevations and renal scarring in children with acute pyelonephritis.", *Scandinavian Journal of Urology & Nephrology*, vol. 43, no. 2, pp. 133-137.
77. Sheu, J.N., Chen, M.C., Lue, K.H., Cheng, S.L., Lee, I.C., Chen, S.M. & Tsay, G.J. 2006, "Serum and urine levels of interleukin-6 and interleukin-8 in children with acute pyelonephritis.", *Cytokine*, vol. 36, no. 5-6, pp. 276-282

Bibliography

65. Pashapour, N., Nikibakhsh, A.A. & Golmohammadlou, S. 2007, "Urinary tract infection in term neonates with prolonged jaundice.", *Urology Journal*, vol. 4, no. 2, pp. 91-94.
66. Pennesi, M., Travan, L., Peratoner, L., Bordugo, A., Cattaneo, A., Ronfani, L., Minisini, S., Ventura, A. & North East Italy Prophylaxis in VUR study, group 2008, *Pediatrics*, vol. 121, no. 6, pp. e1489-94.
67. Pohl A. 2009, Modes of administration of antibiotics for symptomatic severe urinary tract infections. *Cochrane Database of Systematic Reviews*, 2009.
68. Prais, D., Shoov-Furman, R. & Amir, J. 2009, "Is ritual circumcision a risk factor for neonatal urinary tract infections?.", *Archives of Disease in Childhood*, vol. 94, no. 3, pp. 191-194.
69. Pryles CV, Atkin MD, Morse TS, et al. 1959, Comparative bacteriologic study of urine obtained from children by percutaneous suprapubic aspiration of the bladder and by catheter. *Pediatrics* 1959;24:983-91.
70. Riboldi, P., Gerosa, M. & Meroni, P.L. 2009, "Pidotimod: a reappraisal", *International Journal of Immunopathology & Pharmacology*, vol. 22, no. 2, pp. 255-262.
71. Rodriguez, L.M., Robles, B., Marugan, J.M., Suarez, A. & Santos, F. 2008, "Urinary interleukin-6 is useful in distinguishing between upper and lower urinary tract infections.", *Pediatric Nephrology*, vol. 23, no. 3, pp. 429-433.
72. Roussey-Kesler, G., Gadjos, V., Idres, N., Horen, B., Ichay, L., Leclair, M.D., Raymond, F., Grellier, A., Hazart, I., de Parscau, L., Salomon, R., Champion, G., Leroy, V., Guignonis, V., Siret, D., Palcoux, J.B., Taque, S., Lemoigne, A., Nguyen, J.M. & Guyot, C. 2008, "Antibiotic prophylaxis for the prevention of recurrent urinary tract infection in children with low grade vesicoureteral reflux: results from a prospective randomized study", *Journal of Urology*, vol. 179, no. 2, pp. 674-679.
73. Schneider RE. 2004, *Urologic Procedures*. In: Robert JR, Hedges JR. *Clinical Procedures in Emergency Medicine*. 6(3). 4th ed. Philadelphia, PA: W.B. Saunders Co; 2004: 1098-1100.
74. Seattle, 1999. Seattle Children's Hospital. *Guidelines for Management of Urinary Tract Infections*
75. Shaikh N, Morone NE, Lopez J, et al. 2007, Does This Child Have a Urinary Tract Infection? *JAMA*. 2007; 298(24) 2895-2904.
76. Sheu, J.N., Chen, M.C., Chen, S.M., Chen, S.L., Chiou, S.Y. & Lue, K.H. 2009, "Relationship between serum and urine interleukin-6 elevations and renal scarring in children with acute pyelonephritis.", *Scandinavian Journal of Urology & Nephrology*, vol. 43, no. 2, pp. 133-137.
77. Sheu, J.N., Chen, M.C., Lue, K.H., Cheng, S.L., Lee, I.C., Chen, S.M. & Tsay, G.J. 2006, "Serum and urine levels of interleukin-6 and interleukin-8 in children with acute pyelonephritis.", *Cytokine*, vol. 36, no. 5-6, pp. 276-282

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