

Urologic Clinics of North America
Volume 26 • Number 4 • November 1999
Copyright © 1999 W. B. Saunders Company

719

INFECTIONS IN UROLOGY

EVALUATION AND MANAGEMENT OF PEDIATRIC URINARY TRACT
INFECTIONS

Kelly A. Lindert 1 MD
Linda M. Dairiki Shortliffe 1 2

1 Department of Urology, Stanford University Medical Center (KAL, LMDS)
2 Lucile Salter Packard Children's Hospital at Stanford (LMDS), Stanford, California.

Address reprint requests to

Linda M. Dairiki Shortliffe
Department of Urology
Stanford University Medical Center MC: 5118

300 Pasteur Drive, S-287
Stanford, CA 94305-5118

Urinary tract infections (UTIs) in childhood are neither rare nor insignificant. They can be harbingers of potential underlying

anatomic abnormalities. As a result, children in whom UTIs develop routinely undergo an anatomic evaluation when adults may not. The management of UTIs in children also differs from management in adults. This article describes a rational approach to the evaluation and management of childhood UTIs with relation to the natural history and risk factors.

INCIDENCE

In a recent study by Hoberman and Wald, [30] 5.3% of all emergency room visits for fever in infants were explained by UTI.

Prior to 1 year of age, boys have a higher risk for UTI than girls (2.7% versus 0.7%). [70] This observation is especially true for uncircumcised boys, who have a tenfold increase in the risk of having a UTI before the age of 6 months when compared with circumcised boys. [57] [75] With advancing age, these risks reverse; UTIs develop in 3% of school age girls versus 1.1% of boys in the same age group. [72] By young adulthood, the risk of symptomatic UTI in females rises to between 3.3% and 5.8%. [45] [46] In this same age group of males, large-scale epidemiologic screening studies for asymptomatic bacteriuria have not been conducted frequently owing to the low incidence of UTI. [52]

BACTERIA

As is true in the adult population, the most frequently isolated organisms in pediatric UTIs are enteric gram-negative bacteria.

Escherichia coli is the most common bacterium associated with childhood UTIs. Aerobic gram-negative bacteria including members of the Enterobacteriaceae family such as *Citrobacter*, *Enterobacter*, *Klebsiella*, *Proteus*, *Serratia*, and *Salmonella* are also identified. Other organisms seen include the nonenteric, aerobic gram-negative rod *Pseudomonas*; aerobic gram-positive cocci such as enterococcus; and, in neonates, group B *Streptococcus*. Anaerobic bacteria are rarely seen in childhood UTIs despite their abundance in the fecal flora. [14]

VIRULENCE FACTORS

Recent clinical experience indicates that some bacterial strains of *E. coli* have greater potential than others to cause

pyelonephritis. The more virulent strains of this bacterium possess structures called fimbriae or pili. These hair-like structures extend from the outer membranes of the bacterium. Fimbriae facilitate binding of *E. coli* to carbohydrate receptors of urothelial cells. Once situated within the urinary tract, some bacteria may produce an inflammatory response and endotoxins

720

that may inhibit ureteral peristalsis and allow infection to ascend. This activity may explain how children without vesicoureteral reflux can sustain pyelonephritis.

Another marker for *E. coli* virulence is a feature called mannose-resistant hemagglutination. Fimbriae of bacteria facilitate attachment not only to uroepithelial cells but also to carbohydrates located on red blood cells. This attachment leads to agglutination of red blood cells when exposed to these bacteria. Agglutination can be blocked by the addition of sugars, such as mannose, to the environment. Kallenius and co-workers [39] noted that certain strains of *E. coli* more likely to cause pyelonephritis were able to resist mannose's blockade of hemagglutination.

HOST SUSCEPTIBILITY FACTORS

Several factors may influence a child's susceptibility to UTI. [62] Age less than 1 year is one such risk factor, which is explained

in part by the immaturity of a child's immune system at that age. Gender is another risk factor. Among children aged less than 1 year, males are more inclined to sustain UTI than females. The presence of a foreskin also elevates the male infant's risk for UTI. After the age of 1 year, these odds reverse.

Voiding dysfunction has been associated with the development of UTIs. It has been hypothesized that UTI may develop in girls with voiding dysfunction because of backflow of urine laden with urethral bacteria, a phenomenon that results from the voiding dysfunction. [6] Conversely, many children with recurrent UTIs are found to have abnormal urodynamic studies even in the absence of any neurologic abnormalities. [5]

Many of these children with voiding dysfunction and recurrent UTI also have functional constipation on manometry studies. [53] Several investigators have noted that the treatment of voiding dysfunction, constipation, or both may result in a decreased incidence of UTI. [5] [41] [42] [53]

The presence of periurethral colonization is another risk factor. The rate of colonization in the periurethral region is highest in the first few months of life. [9] This coincides with the rate of developing UTI. The rate of colonization with aerobic bacteria drops off significantly thereafter. In fact, it has been shown that the majority of older children with repeated UTIs have persistent periurethral colonization. [9] [10] [66] Ineffective emptying of urine from the bladder can lead to stagnation and overgrowth by bacteria. Children with a history of neurogenic bladder or urinary obstruction (such as posterior urethral valves) have an elevated risk for UTI.

The relationship of red blood cells and human leukocyte antigen (HLA) phenotype expression with the risk for UTI is controversial. In studies of women, the presence of the so-called "nonsecretor" phenotype (i.e., Lewis Lea-b- and Lea+b-) was associated with a significantly elevated risk for UTI as compared with risk in women with "secretor" phenotype (i.e., Lea- b+). [60] These same investigators found no difference in the susceptibility to UTI among ABO blood groups. Other researchers have failed to observe this same relationship in their populations of patients with UTI. [32] [47] Furthermore, Lewis antigen expression on epithelial cells may vary over time. [50] [51] Additional investigation is necessary to clarify the relationship between antigen expression in blood and HLA groups and the susceptibility to UTI.

NATURAL HISTORY OF URINARY TRACT INFECTIONS

There is no clear way to anticipate whether a given child will manifest symptoms of cystitis alone or experience pyelonephritis.

Clinical findings such as fever and flank pain correlate poorly with upper tract localization of bacteria, as demonstrated using the Fairley ureteral catheterization technique. [15] This absence of reliable signs of pyelonephritis may make treatment choices confusing for the practitioner.

The situation is further confounded by the inability to predict clinically which children will have renal scarring. Using intravenous pyelography (IVP), Winberg and co-workers [72] noted that 6.4% of children had scarring after their first symptomatic UTI. In 58% of these patients, scarring was progressive despite adequate treatment and thorough follow-up. This finding is supported in a study by Jodal [38] wherein a direct relationship was noted between the number of episodes of pyelonephritis and the percentage of children in whom renal scarring developed. Specifically, fewer than 10% of children were noted to have renal scarring with their first episode of pyelonephritis; however, 58% of children had

renal scarring if they had four or more episodes of pyelonephritis.

To some extent, the amount of scarring noted is dependent on the age at which the child first sustains a UTI. Ditchfield and co-workers [18] found that early scarring in the setting of UTI was nearly two times more likely in children with UTIs under the age of 2 years when compared with older children (33% versus 17%). Nevertheless, the risk for new scars with UTI persists until at least age 14 to 18 years, as does the risk of progression of previous scars. [61] [65]

Frequently, UTIs may recur. In fact, according to Winberg's studies, 18% of boys sustaining a UTI at less than 1 year of age progressed to another UTI within that first year. If a boy is older than 1 year of age at the time of a first UTI, the risk for a second UTI rises to 32%. If a girl sustains a UTI prior to 1 year of age, she will have a 26% risk for a second UTI. The risk rises to 40% if the initial infection is manifest after the age of 1 year. Winberg also noted in the same study that the more UTIs a child sustains, the greater the risk for a repeat UTI later in life. This likelihood of recurrence is the same irrespective of whether the child is febrile at initial presentation. [72]

RENAL SCARRING AND HYPERTENSION

In the years before broad-spectrum antimicrobial use, childhood UTI was often associated with renal scarring, hypertension,

end-stage renal disease, and even death. Many of these sequelae have been minimized with changes in antibiotics and practices. Nevertheless, the development of renal scarring may be a concerning sign. There is a reasonable association between renal scarring and vesicoureteral reflux. Specifically, 37% to 92% of renal scarring may be affiliated with the presence of vesicoureteral reflux. [36] [64] [73] After excluding other anatomic abnormalities, 7% to 62% of children will have scarring after UTI without any reflux or obstruction. Other possible explanations for the development of scarring in the absence of vesicoureteral reflux may include the presence of more virulent strains of bacteria versus other host resistance factors. Another explanation is based on the observation that many children with vesicoureteral reflux already have evidence of scarring without infection on the first imaging study. [55] In some cases, this scarring may actually represent congenital dysplasia.

Of significant concern to most physicians is the future of the scarred kidney. Jacobson and associates [33] studied the outcome of 30 patients with scarring as the result of

childhood pyelonephritis. Ten percent of these patients had progressed to end-stage renal disease and 23% to hypertension at the time of follow-up. None of these patients had obstructive abnormalities of the urinary tract or diabetes. The average age at follow-up was 33 years. [33] In contrast, Wolfish and associates [76] found no patients in a group of 146 with a history of vesicoureteral reflux in whom hypertension developed after 9.6 years despite the presence of scarring in 34%. Specifically excluded from this study were patients with evidence of dysplasia. Furthermore, the duration of follow-up was shorter than in the Jacobson study. The current consensus is that parents of children with scarring following UTI should be warned of the risk for hypertension owing to the renal injury.

DIAGNOSIS

Symptoms of UTI in children can be difficult to discern. In a child less than 2 years of age, fever, malodorous urine, irritability,

poor feeding, emesis, suprapubic discomfort, diarrhea, and lethargy have been presenting symptoms; however, none of these symptoms is definitive for UTI. Children older than 2 years may be able to report symptoms such as dysuria or suprapubic discomfort or may manifest new problems with continence after toilet training, but none of these developments signifies a specific revelatory symptom of UTI. Often, UTI is diagnosed only as part of a thorough work-up for fever in an otherwise asymptomatic child. The diagnosis is further confounded by the fact that, frequently (5.1%), nonurinary sources for fever such as upper respiratory tract or otitis media are present concomitant with UTI. [28] Because of its overall frequency within the pediatric population, UTI should always be remembered as a possible source for fever, even in children with another localized source.

In children who have unexplained fever, UTI must be suspected. Controversy remains regarding the best way to identify infection in this setting. Inherent to this discussion is the desire expressed by both physicians and parents to minimize trauma to the child during

722

urinary collection. Traditionally, urine has been collected by the "bag" method in which a collection bag is attached to the perineum until the child voids, the "clean-catch" method in which the child voids into a specimen container, urethral catheterization, or suprapubic aspiration in which the abdominal wall is cleansed and a 22-gauge needle inserted 1 to 2 cm above the symphysis pubis for aspiration of urine from the bladder. [3] Bagged urine collection is most convenient and least invasive but is associated with a contamination rate of 10%. [71] Although this risk can be diminished somewhat by fastidious perineal

cleansing and prompt removal of the collection bag, this method of urine collection is unacceptable. [17] Clean-catch specimens are frequently contaminated by periurethral flora in young girls and young uncircumcised boys who may not be totally toilet-trained. Although many physicians argue that catheterization is the most reliable method for the diagnosis of UTI, these cultures may also be contaminated by periurethral flora if the first few milliliters of urine collected is not discarded at the time of collection. Furthermore, catheterization may inoculate an otherwise sterile bladder with bacteria at the time of the procedure.

Suprapubic aspiration is no more invasive than catheterization (especially if topical anesthesia is used), and it is significantly more sensitive in detecting UTIs. Because the needle is introduced directly into the bladder rather than traveling through the urethra, no periurethral organisms can contaminate the specimen. As a result, any identifiable growth on culture from a suprapubic aspiration specimen is considered significant for infection, except possibly for the presence of 3000 colony-forming units (CFU) mL or fewer of coagulase-negative staphylococcus. [25] In separate studies by Pylkkanen [54] and Hansson [24] comparing suprapubic aspiration with clean-catch specimens, UTI in 19% to 20% of children found by suprapubic aspiration would have been undetected in the voided specimen based on a bacterial count cut-off of 50,000 CFU/ mL. Suprapubic aspiration is the most accurate method for detecting UTI in children.

Once the urine specimen is collected, urinalysis may be helpful in diagnosing the presumptive UTI. There are two parts of the urinalysis--dipstick analysis and microscopic examination of the sediment from a centrifuged urine sample. The dipstick analysis examines for leukocyte esterase and nitrites as indicators of UTI. Leukocyte esterase is an enzymatic marker for white blood cells within the urine, and urinary nitrites reflect the presence of urea-splitting bacteria. The dipstick test with indicators for these two substances is quick and easy to use; however, when dipstick analysis was compared with cultures performed on first-morning voided specimens from hospitalized patients, a 22% false-negative rate was found by Zaman and co-workers [77] in specimens deemed positive by the presence of either urinary nitrites or leukocyte esterase. Furthermore, the specificity for infection was only 75% using either of these indicators. Thus the dipstick test alone is unsuitable for UTI diagnosis in children.

The second portion of the urinalysis is microscopic analysis. The identification of bacterial rods on microscopic examination suggests infection; however, this finding alone may reflect contamination of the urine specimen. In the study by Zaman and colleagues, [77] the presence of bacteria alone on microscopic inspection of first-morning, clean-catch specimens produced a 40% false-positive rate when these same specimens were cultured. Many practitioners rely on finding leukocytes within the urine or pyuria. This finding may indicate the presence of localized immune response to infection. Hoberman and co-workers [29] found that 10 white blood cells/muL in combination with bacteria in catheterized specimens had a positive predictive value of 88.3% for detecting UTI. Turner and Coulthard [68] noted that fever alone could induce pyuria in children. Furthermore, Crain and Gershel [17] noted in their study that among febrile infants (<8 weeks old) with UTIs, the diagnosis would have missed in 26% if pyuria alone had been

used as a criterion for UTI. These data serve as a reminder that pyuria alone is unreliable for detecting UTI.

Given the fact that the diagnosis of a UTI in the pediatric population may require further investigation, it is critical that an accurate quantitative urine culture be performed. Given the risks of contamination in non-suprapubic aspiration specimens, the amount of bacterial growth required for this diagnosis has been hotly debated. Traditionally, bacterial growth greater than 100,000 CFU/mL in clean-catch and bag specimens and greater than 50,000 CFU/mL in catheterized specimens has been viewed as the minimal growth needed to diagnose infection [29] [40] ; however, other investigators have found that UTIs can

723

be clinically significant with bacterial counts of less than 10,000 CFU/mL in a voided specimen. [11] [67] Several investigators argue that another clinical finding, such as pyuria (defined as >10 WBC/μL), is required for more accurate diagnosis of true UTI. [29] [44] Clinical suspicion may ultimately determine whether the growth seen on culture is indicative of infection.

TREATMENT

A delay in treatment of UTI leads to a greater chance of renal scarring [35] ; thus prompt diagnosis and treatment of UTI are

essential to minimize morbidity. The need for inpatient or outpatient management of a UTI is dependent on the age of the child and the severity of illness. If the child is less than 3 months old or is unable to take liquids or medications, is dehydrated, immunocompromised, or at risk for poor compliance in follow-up, he or she should be hospitalized and treated with parenteral antibiotics and rehydration.

In hospitalized children, treatment may be initiated with broad-spectrum antibiotic coverage, such as the combination of ampicillin plus an aminoglycoside or a third-generation cephalosporin plus aminoglycoside, until urine culture results and sensitivities return (Table 1) . This combination of antibiotics covers most of the usual urologic pathogens; however, enterococcus may be resistant to cephalosporins. Parenteral treatment is usually continued until the child is afebrile and antibiotic sensitivities to the infecting organism return. At that point, the child may be switched to appropriate oral antibiotic coverage to complete 7 to 14 days of treatment. Common oral antibiotics are listed in Table 1 . Thereafter, the child should be given prophylactic antibiotics until an imaging evaluation for underlying anatomic abnormalities is completed. Potential prophylactic antibiotics are also listed in Table 1 .

Children who are able to take fluids and who are not severely ill can be managed as outpatients as long as there is clinical improvement. Either parenteral or oral antibiotics may be selected, and several of these are

TABLE 1 -- ANTIBIOTICS FOR TREATMENT OF URINARY TRACT INFECTION IN CHILDREN

Antibiotic
Treatment Route
Prophylactic Dose
Precautions

Amoxicillin
PO
5 mg/kg qhs
1

Amoxicillin-clavulanate (Augmentin)
PO
Not recommended
2

Ampicillin
IV, IM, PO
Not studied
None

Cefaclor
PO
10-20 mg/kg qhs
3

Cefadroxil
PO
Not studied
None

Cefotaxime
IV, IM
Not applicable
4

Ceftazidime
IV, IM
Not applicable
4

Ceftriaxone
IV, IM
Not applicable
4, 5, 6

Cefuroxime
PO
Not studied
3

Cephalexin
PO
2-5 mg/kg qhs
7

Gentamicin
IV, IM
Not applicable
8, 9

Loracarbef
PO
Not studied
3

Nalidixic acid
PO
12.5 mg/kg qhs
10, 11

Nitrofurantoin
PO
1-1.5 mg/kg qhs
5, 10, 12

Sulfisoxazole
PO
5-10 mg/kg qhs
5

Trimethoprim (also TMP-SMX based on
trimethoprim dose)
PO
2 mg/kg qhs
None

PO = by mouth; IV = intravenous; IM = intramuscular.

- 1 Associated with a moderate rate of resistant strains of bacteria. [26]
 - 2 Use should be reserved for situations in which an amoxicillin-resistant organism is suspected. [16]
 - 3 Second-generation cephalosporins are not as effective against *Pseudomonas* and enterococcus.
 - 4 Associated with resistant strains of enterococcus; not recommended as drug of first choice for recurrent infections.
 - 5 Not for use in children under 6 weeks of age.
 - 6 Not for use in children with hepatic insufficiency.
 - 7 Recommended for use in prophylaxis for infants less than 6 weeks of age.
 - 8 Associated with ototoxicity and nephrotoxicity; dosing should be adjusted according to renal function and serum levels followed closely.
 - 9 Use of IM form as outpatient is advised primarily in children with a history of allergy to cephalosporins.
 - 10 Not recommended for use in children who appear toxic or febrile owing to limited tissue distribution.
 - 11 Associated with a moderate rate of bacterial resistance. [27]
 - 12 Not for use in children with glucose-6-phosphate dehydrogenase deficiency.
- Data from references [13] [20] [26] [59] [62] and [78] .

724

listed in Table 1 . Parents should be aware that they should contact the physician if the child fails to improve.

Many oral antibiotics offer excellent coverage against most organisms causing nonhospital-acquired UTIs. Some of these antibiotics are listed in Table 1 . Amoxicillin is commonly used for the treatment of UTI; however, the penicillinase-resistant form, amoxicillin-clavulanate, covers a wider spectrum of organisms. The routine use of amoxicillin-clavulanate is not recommended owing to concerns of further development of bacterial resistance. The cephalosporins and trimethoprim- sulfamethoxazole are also useful oral agents. Nitrofurantoin will not achieve high tissue and serum concentrations, but it concentrates in the urine, making it useful for treatment of cystitis and for prophylaxis. Fluoroquinolones other than nalidixic acid are not approved for routine use in the treatment of pediatric UTI owing to their association with cartilage erosion in young animal studies. [31]

Antibiotic prophylaxis should be considered in any child with a history of UTI until full evaluation for anatomic abnormality is complete. Prophylaxis is recommended in an infant aged less than 3 to 6 months with a history of UTI and in a child with vesicoureteral reflux, partial obstruction, or immunosuppression. Prophylaxis may also be considered in children with a history of recurrent symptomatic UTI without underlying anatomic abnormality. Commonly used prophylactic antibiotics for children are listed in Table 1 . The ideal prophylactic antibiotic provides high urinary antibiotic excretion with low serum and fecal levels. This distribution minimizes the development of resistant bacterial strains in the fecal flora. Growth of resistant strains can occur even within the setting of the initial treatment of UTI.

RADIOLOGIC EVALUATION

Frequently, UTIs herald the presence of underlying abnormalities. In studies by Kunin and co-workers, [46] 20.6% of children

undergoing IVP for the evaluation of UTI demonstrated abnormalities, and 37.4% of children had abnormal voiding cystourethrography (VCUG). Between 21% and 54% of children with asymptomatic bacteriuria have been found to have vesicoureteral reflux. [1] [2] [46] [52] [72] In one study, 6.3% had ureteral duplication, and 16% had combinations of trabeculated bladders, hydroureter, and ureteropelvic junction obstruction. [52] Given the frequency with which these abnormalities occur, upper and lower urinary tract imaging studies should be performed in children after their first proven UTI.

No single radiologic study can successfully evaluate a child for both upper and lower urinary tract anatomic abnormalities; therefore a minimum of two imaging studies is necessary to rule out such abnormalities. Ultrasound is helpful in evaluating the upper urinary tracts for hydronephrosis, duplicated systems, scarring, and hydroureter. It is typically the first imaging study performed. Nevertheless, ultrasound is unable to evaluate for reflux, function, or functional obstruction. IVP offers excellent anatomic detail of the upper tract collecting system and can provide an approximate indication of renal function and scarring; however, it also provides significant radiation exposure.

Radionuclide scans, such as with ^{99m}Tc-technetium- dimercaptosuccinic acid (DMSA), are helpful in assessing for renal inflammation and scarring but lack anatomic detail for the assessment of urinary tract anomalies.

Reflux is the most common anatomic abnormality associated with UTI. As a result, VCUG is part of the imaging evaluation of a UTI. This study will not only demonstrate reflux but will reveal urethral and bladder abnormalities as well. VCUG may be performed as soon as the urine becomes sterile after treatment for UTI and after bladder spasms abate and bladder volume returns to normal, typically within 1 to 6 weeks following the initial infection. Fluoroscopic VCUG is preferred over radionuclide VCUG for the first evaluation of the lower tract because of its anatomic detail of the calices and urethra.

Because of the association among UTI, renal scarring, and hypertension, the DMSA scan has received attention for its ability to localize pyelonephritis in a noninvasive fashion. Giblin and co-workers [19] used a piglet model to demonstrate that renal cortical perfusion defects noted on the DMSA scan correlate well (97% sensitivity and 93% specificity) with areas demonstrating histopathologic changes suggestive of acute pyelonephritis. These same areas of hypoperfusion on DMSA in 17% to 75% of instances may evolve into renal scars over the course of the next 2 years. [12] [34] [37] [56] [58] [69] Nevertheless, the correlation

725

is not complete. DMSA is more sensitive than IVP in detecting scars. Goldraich and co-workers [22] found that 34 of 297 kidneys in children with a history of vesicoureteral reflux demonstrated scarring on DMSA scan otherwise missed by IVP. The presence of these scars was confirmed in 88% of these patients on follow-up IVP performed 1 to 3 years later. For this reason, DMSA scans performed several months after acute pyelonephritis in a young child may be useful to assess for renal scarring.

Evaluation for acute and chronic pyelonephritis with ultrasound is controversial. When Benador and associates [8] compared the sensitivity of ultrasound with that of DMSA scan in 111 patients, the sensitivity of ultrasound was, at best, only 50% in finding abnormalities in a symptomatic child. In contrast, Barry and co-workers [4] found that using specific criteria such as loss of pyramids, proximity of sinus echoes to cortical surface, and caliceal dilatation, ultrasound had a positive predictive value of 93% in assessing renal scarring when compared with DMSA.

The DMSA scan may be useful for patients in whom the diagnosis of pyelonephritis may affect management. For instance, if doubt exists concerning the validity of a positive urine culture (e.g., a bagged urine specimen), the presence of renal inflammation on DMSA scan may warrant parenteral antimicrobial treatment. [63] Likewise, the presence

of scarring on a DMSA scan in a child with recurrent pyelonephritis suggests the need for further investigation to reevaluate for vesicoureteral reflux.

MANAGEMENT

The prevention of recurrent UTI is an essential aspect of management. As stated previously, antimicrobial prophylaxis should

be initiated in children after the diagnosis of UTI until further anatomic evaluation is complete. Surveillance for infection is also important. Parents and pediatricians should be reminded to perform a catheterized or suprapubic aspiration urine culture in febrile children with a history of UTI. Minimizing host susceptibility factors, when possible, may be beneficial. The improvement of voiding dysfunction, associated poor bladder habits, and constipation is associated with a lower rate of bacteriuria. Circumcision may be of benefit in an infant less than 6 months of age because a higher incidence of periurethral bacterial colonization is present in uncircumcised males for the first 6 months of life. [21] [23] [74]

Although many children undergoing radiologic evaluation for UTI demonstrate an underlying anatomic abnormality, their surgical management will be specific to their anatomic abnormality. The ultimate goal of management is to minimize renal damage while recognizing the natural course of these abnormalities. Vesicoureteral reflux is the most common diagnosis. Vesicoureteral reflux may resolve spontaneously at a rate dependent on the grade of reflux and the child's age at diagnosis. [7] Furthermore, research in animals suggests that vesicoureteral reflux poses no threat to the kidney if bladder activity is normal and the urine remains uninfected. Younger children with vesicoureteral reflux should remain on prophylactic antibiotic therapy until the reflux resolves or surgical correction is elected.

With obstructive lesions such as ureteropelvic junction obstruction, prophylaxis might be considered until the underlying lesion is repaired successfully. Surgically correctable anatomic abnormalities that may cause bacterial persistence are urinary fistulae, medullary sponge kidney, urachal cysts, and urethral diverticulae. Because these lesions have the potential of becoming a nidus for UTI, the use of prophylactic antibiotics may be prudent in some of these situations.

Children with a history of an isolated UTI and no demonstrable anatomic abnormality after upper and lower urinary tract imaging studies may not require further studies or treatment. If they are older than 6 months and are healthy, these children may be taken off prophylaxis as well. Children with recurrent symptomatic UTIs and no anatomic abnormality may benefit from further antimicrobial prophylaxis and observation. In a child in whom vesicoureteral reflux is not detected but who continues to have symptoms of pyelonephritis, a nuclear VCUG may be useful because evidence suggests that this

study is more sensitive than fluoroscopic VCUG in detecting vesicoureteral reflux. [43]
[49]

CONCLUSION

The goal of management in pediatric UTIs is to minimize future morbidity in the child.

726

Prompt, appropriate, and thorough evaluation of UTIs in this population of patients is key. Children must be evaluated using

the most accurate culture method possible because proper diagnosis of UTI will lead to an imaging evaluation that involves invasive tests. Early treatment with appropriate antibiotics is important. Because a significant number of these children have underlying anatomic abnormalities, radiologic imaging should be performed after the first UTI. When the imaging evaluation is incomplete, the detection of children at risk for renal damage from further UTIs will be impaired. Children with renal scarring should be observed for signs of proteinuria and hypertension in adolescence and early adulthood.

References

1. Abbott GD: Neonatal bacteriuria: A prospective study in 1460 infants. *BMJ* 1:267-269, 1972
2. Asscher AW: Urinary tract infection: The value of early diagnosis. *Kidney Int* 7:63-67, 1975 Citation
3. Barkemeyer B: Suprapubic aspiration of urine in very low birth weight infants. *Pediatrics* 92:457-459, 1993 Citation
4. Barry BP, Hall N, Cornford E, et al: Improved ultrasound detection in renal scarring in children following urinary tract infection. *Clin Radiol* 53:747-751, 1998 Abstract
5. Bauer SB, Retik AB, Colodny AH, et al: The unstable bladder of childhood. *Urol Clin North Am* 7:321-336, 1980 Abstract
6. Bauer SB: Neuropathology of the lower urinary tract. In Kelalis PP, King LR, Belman AB (eds): *Clinical Pediatric Urology*, ed 3. Philadelphia, WB Saunders, 1992, pp 399-400

7. Bellinger MF, Duckett JW: Vesicoureteral reflux: A comparison of nonsurgical and surgical management. *Contrib Nephrol* 39:81-93, 1984 Citation
8. Benador D, Benador N, Slosman DO, et al: Cortical scintigraphy in the evaluation of renal parenchymal changes in children with pyelonephritis. *J Pediatr* 124:17-20, 1994 Abstract
9. Bollgren I, Winberg J: The periurethral aerobic bacterial flora in healthy boys and girls. *Acta Paediatr Scand* 65:74-80, 1976 Abstract
10. Bollgren I, Winberg J: The periurethral aerobic flora in girls is highly susceptible to urinary infections. *Acta Paediatr Scand* 65:81-87, 1976 Abstract
11. Bollgren I, Engstroem CF, Hammarlind M, et al: Low urinary counts of P-fimbriated *Escherichia coli* in presumed acute pyelonephritis. *Arch Dis Child* 59:102-106, 1984 Abstract
12. Bouissou F, Danet B, Belmonte D, et al: DMSA scan in acute pyelonephritis in 150 children [abstract]. *Pediatr Nephrol* 4:C44, 1990
13. Brendstrup L, Hjelt K, Petersen KE, et al: Nitrofurantoin versus trimethoprim prophylaxis in recurrent urinary tract infections in children. *Acta Paediatr Scand* 79:1225-1234, 1990
14. Brook I: Urinary tract infections caused by anaerobic bacteria in children. *Urology* 16:596-598, 1980 Abstract
15. Busch R, Huland H: Correlation of symptoms and results of direct bacterial localization in patients with urinary tract infections. *J Urol* 132:282-285, 1984 Abstract
16. Committee on Safety of Medicines and the Medicines Control Agency: Revised indications for co-amoxiclav (Augmentin). *Curr Probl Pharmacovigilance* 23:8, 1997
17. Crain E, Gershel J: Urinary tract infections in febrile infants younger than 8 weeks of age. *Pediatrics* 86:363-367, 1990 Abstract
18. Ditchfield MR, de Campo JF, Nolan TM, et al: Risk factors in the development of early renal cortical defects in children with urinary tract infections. *AJR Am J Roentgenol* 162:1393-1397, 1994 Abstract
19. Giblin JG, O'Connor KP, Fildes RD, et al: The diagnosis of acute pyelonephritis in the piglet using single photon emission computerized tomography dimercaptosuccinic acid scintigraphy: A pathological correlation. *J Urol* 150(2 Pt 2):759-762, 1993 Abstract

20. Ginsburg CM, McCracken GH Jr, Clarkson G, et al: Clinical pharmacology of cefadroxil in infants and children. *Antimicrob Agents Chemother* 13:845-848, 1978
Citation
21. Glennon J, Ryan PJ, Keane CT, et al: Circumcision and periurethral carriage of *Proteus mirabilis* in boys. *Arch Dis Child* 63:556-557, 1988 Abstract
22. Goldraich NP, Ramos OL, Goldraich IH: Urography versus DMSA scan in children with vesicoureteral reflux. *Pediatr Nephrol* 3:1-5, 1989 Abstract
23. Hallett RJ, Pead L, Maskell R: Urinary infection in boys: A three-year prospective study. *Lancet* 2:1107-1110, 1976 Abstract
24. Hansson S, Brandstrom P, Jodal U, et al: Low bacterial counts in infants with urinary tract infection. *J Pediatr* 132:180-182, 1998 Full Text
25. Hellerstein S: Recurrent urinary tract infections in children. *Pediatr Infect Dis* 1:271-281, 1982 Citation
26. Hellerstein S: Urinary tract infections. *Pediatr Clin North Am* 42:1433-1457, 1995 Abstract
27. Hendershot EF: Fluoroquinolones. *Infect Dis Clin North Am* 9:715-730, 1995 Abstract
28. Hoberman A, Chao H, Keller D, et al: Prevalence of urinary tract infection in febrile infants. *J Pediatr* 123:17-23, 1993 Abstract
29. Hoberman A, Wald E, Reynolds E, et al: Pyuria and bacteriuria in urine specimens obtained by catheter from young children with fever. *J Pediatr* 124:513-519, 1994 Abstract
30. Hoberman A, Wald ER: Urinary tract infections in young febrile children. *Pediatr Infect Dis J* 16:11-17, 1997 Abstract
31. Hooper DC: Quinolones. In Mandell GL, Bennett JE, Dolin R (eds): *Principles and Practice of Infectious Diseases*, ed 4. New York, Churchill Livingstone, 1995, pp 364-376
32. Hopkins WJ, Heisery DM, Lorentzen DF, et al: A comparative study of major histocompatibility complex and red blood cell antigen phenotypes as risk factors for recurrent urinary tract infections in women. *J Infect Dis* 177:1296-1301, 1998 Abstract
33. Jacobson SH, Eklof O, Eriksson CG, et al: Development of hypertension and uremia after pyelonephritis in childhood: 27 Year follow up. *BMJ* 299(6701):703-706, 1989

34. Jakobsson B, Lewander R, Notstedt L, et al: 99-Tc-DMSA scintigraphy in acute pyelonephritis in children [abstract]. *Pediatr Nephrol* 4:C44, 1990

35. Jakobsson B, Nolstedt L, Svensson L, et al: 99m technetium-dimercaptosuccinic

727

acid scan in the diagnosis of acute pyelonephritis in children: Relation to clinical and radiological findings. *Pediatr Nephrol* 6:328-334, 1992 Abstract

36. Jakobsson B, Berg U, Svensson L: Renal scarring after acute pyelonephritis. *Arch Dis Child* 70:111-115, 1994 Abstract

37. Jewkes FEM, Gupta SC, Wilson B, et al: DMSA scanning in acute urinary tract infection (UTI) and its relationship to vesicoureteral reflux [abstract]. *Pediatr Nephrol* 4:C44, 1990

38. Jodal U: The natural history of bacteriuria in childhood. *Infect Dis Clin North Am* 1:713-729, 1987 Abstract

39. Kallenius G, Mollby R, Svenson SB, et al: Occurrence of P-fimbriated *Escherichia coli* in urinary tract infections. *Lancet* 2:1369-1372, 1981 Citation

40. Kass EH, Finland M: Asymptomatic infections of the urinary tract. *Trans Assoc Am Physicians* 69:56-64, 1956

41. Kjolseth D, Knudsen LM, Jadsen B, et al: Urodynamic biofeedback training for children with bladder-sphincter dyscoordination during voiding. *Neurourol Urodyn* 12:211-221, 1983

42. Koff SA, Lapidus J, Piazza DH: Association of urinary tract infection and reflux with uninhibited bladder contractions and voluntary sphincter obstruction. *J Urol* 122:373-376, 1979 Abstract

43. Kogan SJ, Sigler L, Levitt SB, et al: Elusive vesicoureteral reflux in children with normal contrast cystograms. *J Urol* 136:325-328, 1986 Abstract

44. Kramer M, Tange S, Drummond K, et al: Urine testing in young febrile children: A risk-benefit analysis. *J Pediatr* 125:6-13, 1994 Abstract

45. Kunin CM, Zacha E, Paquin AJ: Urinary tract infections in schoolchildren. *N Engl J Med* 266:1287-1296, 1962

46. Kunin CM, Deutscher R, Paquin A: Urinary tract infection in schoolchildren: An epidemiologic, clinical and laboratory study. *Medicine* 43:91-130, 1964
47. Lichodziejewska-Niermierko M, Topley N, Smith C, et al: P1 blood group phenotype, secretor status in patients with urinary tract infections. *Clin Nephrol* 44:376-379, 1995 Abstract
48. LiPuma JJ, Stull TL: Antibacterial agents in pediatrics. *Infect Dis Clin North Am* 9:561-574, 1995 Abstract
49. MacPherson RI, Gordon L: Vesicoureteric reflux: Radiologic aspects. *Semin Urol* 6:89-98, 1986 Citation
50. Navas EL, Venegas MF, Duncan JL, et al: Blood group antigen expression on vaginal and buccal epithelial cells and mucus in secretor and nonsecretor women. *J Urol* 149:1492-1498, 1993 Abstract
51. Navas EL, Venegas MF, Duncan JL, et al: Blood group antigen expression on vaginal cells and mucus in women with and without a history of urinary tract infections. *J Urol* 152(2 Pt 1):345-349, 1994 Abstract
52. Newcastle Asymptomatic Bacteriuria Research Group: Asymptomatic bacteriuria in schoolchildren in Newcastle upon Tyne. *Arch Dis Child* 50:90-131, 1975 Abstract
53. O'Regan S, Yazbeck S, Schick E: Constipation, bladder instability, urinary tract infection syndrome. *Clin Nephrol* 23:152-154, 1985 Abstract
54. Pylkkanen J, Vilksa J, Koskimies O: Diagnostic value of symptoms and clean-voided urine specimen in childhood urinary tract infection. *Acta Paediatr Scand* 68:341-344, 1979 Abstract
55. Risdon RA: The small scarred kidney of childhood: A congenital or an acquired lesion. *Pediatr Nephrol* 1:632-637, 1987 Abstract
56. Rosenberg AR, Rossleigh MA, Brydon MP, et al: Evaluation of acute urinary tract infection in children by dimercaptosuccinic acid: A prospective study. *J Urol* 148(5 Pt 2):1746-1749, 1992
57. Rushton H, Majd J: Pyelonephritis in male infants: How important is the foreskin? *J Urol* 148(2 Pt 2):733-736, 1992 Abstract
58. Rushton HG, Majd M: Dimercaptosuccinic acid renal scintigraphy for the evaluation of pyelonephritis and scarring: A review of experimental and clinical studies. *J Urol* 148(5 Pt 2):1726-1732, 1992 Abstract

59. Seracini D, Materassi M, Danti A: Noncomparative open study of the efficacy and tolerance of cefaclor in the prevention of urinary tract infection in children. *Pediatr Med Chir* 18:383-385, 1996 Abstract
60. Sheinfeld J, Schaeffer AJ, Cordon-Cardo C, et al: Association of the Lewis blood group phenotype with recurrent urinary tract infections in women. *N Engl J Med* 320:773-777, 1989 Abstract
61. Shimada K, Matsui T, Ogino T, et al: New development and progression of renal scarring in children with primary VUR. *Int Urol Nephrol* 21:153-158, 1989 Abstract
62. Shortliffe LMD: Urinary tract infections in infants and children. In Walsh PC, Retik AB, Vaughan ED, et al (eds): *Campbell's Urology*, ed 7. Philadelphia, WB Saunders, 1998, pp 1681-1707
63. Shortliffe LMD, Fair WR: Urinary tract inflammation: An overview. In Pollack H, McClennen B (eds): *Clinical Urography*, ed 2. Philadelphia, WB Saunders, in press
64. Smellie JM, Norman ICS, Katz G: Children with urinary infection: A comparison of those with and those without vesicoureteric reflux. *Kidney Int* 20:717-722, 1981 Citation
65. Smellie JM, Ransley PG, Norman ICS, et al: Development of new renal scars: A collaborative study. *BMJ* 290:1957-1960, 1985
66. Stamey TA, Sexton CC: The role of vaginal colonization with Enterobacteriaceae in recurrent urinary infections. *J Urol* 113:214-217, 1975 Abstract
67. Stamm WE, Counts GW, Running KR, et al: Diagnosis of coliform infection in acutely dysuric women. *N Engl J Med* 307:463-468, 1982 Abstract
68. Turner GM, Coulthard MG: Fever can cause pyuria in children. *BMJ* 311(7010):924, 1995 Citation
69. Verboven M, Ingels M, Delree M, et al: 99m Tc-DMSA scintigraphy in acute urinary tract infection in children. *Pediatr Radiol* 20:540-542, 1990 Abstract
70. Wettergren B, Fasth A, Jacobsson B, et al: UTI during the first year of life in a Goteborg area, 1977-1979. *Pediatr Res* 14:981, 1980
71. Wettergren B, Jodal U, Jonasson G: Epidemiology of bacteriuria during the first year of life. *Acta Paediatr Scand* 74:925-933, 1985 Abstract
72. Winberg J, Anderson JH, Bergstroem T, et al: Epidemiology of symptomatic urinary tract infection in childhood. *Acta Paediatr Scand Suppl* 252:1-20, 1974 Citation

73. Winberg J, Bollgren I, Kaellenius G, et al: Clinical pyelonephritis and focal renal scarring. *Pediatr Clin North Am* 29:801-814, 1982 Citation

74. Wiswell TE, Miller GM, Gelston HM, et al: Effect of circumcision status on periurethral bacterial flora during the first year of life. *J Pediatr* 113:442-446, 1988 Abstract

75. Wiswell T, Hachey W: Urinary tract infections and

728

the uncircumcised state: An update. *Clin Pediatr* 32:130-134, 1993 Abstract

76. Wolfish NM, Delbrouck NF, Shanon A, et al: Prevalence of hypertension in children with primary vesicoureteral reflux. *J Pediatr* 123:559- 563, 1993 Abstract

77. Zaman Z, Borremans A, Verhaegen J, et al: Disappointing dipstick screening for urinary tract infection in hospital inpatients. *J Clin Pathol* 51:471-472, 1998 Abstract

78. The management of urinary tract infection in children. *Drug Ther Bull* 35:65-69, 1997 Citation

MD Consult L.L.C. <http://www.mdconsult.com>

Bookmark URL:

[/das/journal/view/22265474/N/11127745?ja=154342&PAGE=1.html&ANCHOR=top&source=MI](http://www.mdconsult.com/das/journal/view/22265474/N/11127745?ja=154342&PAGE=1.html&ANCHOR=top&source=MI)