Urinary Tract Infection in Children

BRIAN S. ALPER, M.D., M.S.P.H., and SARAH H. CURRY, M.D.
University of Missouri–Columbia, Columbia, Missouri

Up to 7 percent of girls and 2 percent of boys will have a symptomatic, culture-confirmed urinary tract infection by six years of age. Urinary tract infection may be suspected because of urinary symptoms in older children or because of fever, nonspecific symptoms, or failure to thrive in infants. Urine dipstick analysis is useful for ruling out urinary tract infections in cases with low clinical suspicion. However, urine culture is necessary for diagnosis of urinary tract infections in children if there is high clinical suspicion, cloudy urine, or if urine dipstick testing shows positive leukocyte esterase or nitrite activity. Despite current recommendations, routine imaging studies (e.g., renal ultrasonography, voiding cystourethrography, renal scans) do not appear to improve clinical outcomes in uncomplicated urinary tract infections. Oral antibiotics are as effective as parenteral therapy in randomized trials. The optimal duration of antibiotic therapy has not been established, but one-day therapies have been shown to be inferior to longer treatment courses. (Am Fam Physician 2005;72:2483-8. Copyright © 2005 American Academy of Family Physicians.)

EB CME

This clinical content conforms to AAFP criteria for evidence-based continuing medical education (EB CME). EB CME is clinical content presented with practice recommendations supported by evidence that has been reviewed systematically by an AAFP-approved source.

Until recently, the management of urinary tract infection (UTI) in children has been controversial and based mainly on opinion, but new evidence regarding imaging studies and treatment prompted this review. Although symptomatic UTI and asymptomatic bacteriuria (i.e., positive urine cultures without symptoms or signs of illness) are discussed in the literature, this review focuses on symptomatic UTI.

Epidemiology

Up to 7 percent of girls and 2 percent of boys will have a symptomatic, culture-confirmed UTI by six years of age.[1] The prevalence of UTI in febrile infants is greater with younger age, with a rate of nearly 7 percent among febrile newborns.[2]

Most UTIs in children result from ascending infections, although hematogenous spread may be more common in the first 12 weeks of life. Most UTIs in children are monomicrobic, often caused by Escherichia coli (60 to 80 percent of cases), Proteus (more common in boys and in children with renal stones), Klebsiella, Enterococcus, and coagulase-negative staphylococci.[3]

Evidence on risk factors for UTI in children is limited. UTIs were associated with constipation, encopresis, bladder instability, and infrequent voiding in two studies[4,5] but not in a cohort of febrile children younger than two years.[6] Bathing and back-to-front wiping have not been demonstrated to be risk factors.

Evaluation

Older children with UTI may have dysuria, frequency, urgency, hesitancy, small-volume voids, or lower abdominal pain. Infants with UTI more commonly present with nonspecific symptoms such as fever, irritability, jaundice, vomiting, or failure to thrive. Unusual odor of the urine is not helpful in predicting UTI.[7]

Other conditions may mimic UTI symptoms. Acute urethritis or vulvovaginitis may be caused by various types of irritants, including chemical (e.g., bubble baths, soaps), physical (e.g., self-exploration), and biologic (e.g., pinworms). Self-infusion of water into the urethra was reported in 10 of 31 boys five to 15 years of age presenting with a first UTI.[8]

URINE CULTURE

Urine culture is required for diagnosis of UTI. The diagnostic threshold depends on the method of urine collection. Compilation of studies comparing counts of colony-forming units from various collection methods with

SORT: KEY RECOMMENDATIONS FOR PRACTICE

Clinical recommendation	*Evidence rating*	*References*
Urine culture should be obtained for diagnosis of UTI in children if there is high clinical suspicion, cloudy urine, or positive urine dipstick.	C	13-16
Routine imaging studies (e.g., ultrasonography, VCUG, renal scans) do not appear to improve outcomes in children with a first uncomplicated UTI, but the evidence is weak.	B	24, 26, 27
Oral antibiotics should be used (when tolerated) instead of parenteral antibiotics to manage UTI in children.	A	35, 36
One-day courses of antibiotics should not be used to manage UTI in children.	A	37
Consider that short courses of antibiotics (two to five days) may be as effective as longer courses (seven to 14 days).	B	37-39
Prophylactic antibiotics may be used to reduce the risk of recurrent UTI.	B	42, 43

UTI = urinary tract infection; VCUG = voiding cystourethrography.

A = consistent, good quality patient-oriented evidence; B = inconsistent or limited quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For more information about the SORT evidence rating system, see page 2416 or http://www.aafp.org/afpsort.xml.

the probability of UTI has established the recommendations listed in Table 1.[9]

For urine collection from infants and young children, suprapubic aspiration or transurethral catheterization generally is recommended. Urethral catheterization is more likely than aspiration to obtain a sufficient sample of urine.[10] Collection from bags or pads leads to high contamination rates.[11] Clean-catch urine collection from infants requires more patience and effort than the use of pads or bags, but this method is reasonably accurate and rates of contamination are low.[11,12]

TABLE 1
Diagnostic Thresholds for UTI in Children

Method of urine collection	*Diagnostic threshold*
Clean-catch voiding in girls	100,000 CFU per mL Repeat testing if 10,000 to 100,000 CFU per mL
Clean-catch voiding in boys	10,000 CFU per mL
Catheter	10,000 CFU per mL Repeat testing if 1,000 to 10,000 CFU per mL
Suprapubic aspiration	Any number of colonies for gram-negative bacilli, more than a few thousand CFU per mL for gram-positive cocci

UTI = urinary tract infection; CFU = colony-forming units.

Adapted with permission from Hellerstein S. Recurrent urinary tract infections in children. Pediatr Infect Dis 1982;1:275.

RAPID URINE TESTING

Children with a high likelihood of UTI (e.g., older children with classic urinary symptoms) should have a urine culture; rapid urine testing will not change the treatment of these patients. In children with a low likelihood of UTI (e.g., those with vague urinary complaints and an alternative explanation for fever), urine inspection and dipstick testing may reduce the need for urine culture. Urine culture is indicated if the child's urine is cloudy or if the dipstick test shows positive leukocyte esterase or nitrite activity.[13-16] Urine culture also is recommended for children with recurrent symptoms.

Urine dipstick analysis can rule out UTI if the result is negative (in nondilute urine), but a positive result on dipstick testing is insufficient to diagnose UTI because false-positive results are common. In a cohort study[13] with 18 percent prevalence of UTI, a negative result on urine dipstick analysis (i.e., negative for leukocyte esterase and nitrites) had a negative predictive value of 96 percent. Urine dipstick analysis appears to be more accurate than microscopic analysis for the detection of pyuria in children,[13,14] although this has been debated.[17] Urine dipstick analysis may produce false-negative results with dilute urine (i.e., specific gravity less than 1.005). Clear urine (defined as the ability to read text through the urine in a test tube as easily as through water) had 96 to 100 percent negative predictive values in cohort studies,[13,15,16] but these values may be unreliable in dilute urine.

Some authors recommend urine culture testing for infants with suspected UTI because of lower sensitivities for urine dipstick analysis in infants.[18,19] However, investigators in several large cohort studies[2,20] of infants younger than two years with undiagnosed fevers or UTI symptoms have found negative predictive values greater than 98 percent despite sensitivities of 79 percent. Urine dipstick testing achieved these high negative predictive values because of the low likelihood of positive urine cultures (2.8 to 8 percent) in these studies.[2,20]

ADDITIONAL TESTING

Blood cultures are unnecessary in most children with UTI, but they are more likely to be positive in children younger than two months and in children whose urine cultures grow Staphylococcus aureus or group B streptococcus.[21,22]

Previously, imaging studies were recommended for any child with a UTI. The 1999 clinical practice guideline[23] from the American Academy of Pediatrics (AAP) recommends imaging for children two months to two years of age, noting that the strength of evidence for the recommendation is fair. Recent evidence has suggested that imaging work-ups for children with a first uncomplicated UTI may not improve patient care. In one prospective study,[24] renal ultrasonography did not change the management of UTI in any of 255 children younger than five years who were admitted with a first uncomplicated febrile UTI. An earlier systematic review[25] of 63 descriptive studies found no evidence of the impact of routine imaging on clinical outcomes in children with a first UTI.

In a randomized trial,[26] 150 children two to 10 years of age with a first UTI were assigned to routine imaging (i.e., ultrasonography and voiding cystourethrography [VCUG]) or to selective imaging (only if recurrent UTI or persistent problems were present). Approximately one in five children (21 percent) in the selective imaging group had imaging performed. Routine imaging increased the use of prophylactic antibiotics (28 versus 5 percent) but did not reduce the rate of recurrent UTIs (26 versus 21 percent) or renal scarring at two years (9 versus 9 percent). These results suggest that imaging is not useful in determining which children might benefit from prophylactic antibiotics.

Extensive imaging work-up (i.e., ultrasonography and renal scan within 72 hours, VCUG at one month, and repeat renal scan at six months) was evaluated in a prospective study[27] of 309 children one to 24 months of age with a first febrile UTI. Results of ultrasonography were normal in 88 percent, and abnormalities did not change management (i.e., no obstructive lesions were found). Initial renal scans suggested acute pyelonephritis in 61 percent of patients, but febrile UTI in infants is managed with the presumption of pyelonephritis. VCUG and repeat renal scans showed vesicoureteral reflux (VUR) and renal scarring in 39 and 9.5 percent of infants, respectively. However, the manner in which VUR or renal scarring should alter the course of management is controversial. In some reviews,[28,29] authors have suggested that VUR predisposes children to recurrent pyelonephritis and renal scarring. Although some children with renal scarring develop hypertension and renal insufficiency in adulthood, this association appears limited to those with extensive renal scarring or hypertension in childhood.[28] Recommendations have been made to identify VUR early to stop this cascade of events, despite a lack of studies showing that interventions along this pathway prevent renal scarring, hypertension, and renal insufficiency. Severe VUR has been associated with recurrent UTI[30] and recurrent pyelonephritis,[31] but the association of VUR with renal scarring has been inconsistent.[32,33] Renal scarring is associated with recurrent UTI[32] and recurrent pyelonephritis,[34] but a causal relationship has not been established.[25]

Surgical and medical management for vesicoureteral reflux do not appear to differ in urinary tract infection recurrence rates, renal function, renal scarring, hypertension, or end-stage renal disease.

Although imaging traditionally has been recommended in children with recurrent UTI, no randomized trials are available to support or refute these recommendations. Bladder ultrasonography to determine postvoid residual volume may identify urinary obstruction, and children with renal scarring may benefit from follow-up for early detection of hypertension or renal insufficiency, but data supporting these approaches are sparse.

Treatment

Empiric antibiotic therapy (Table 2[23]) is reasonable while awaiting culture results if there is a high clinical suspicion of UTI.[23] Subsequently changing antibiotics based on reported sensitivities may be unnecessary if clinical resolution occurs. According to the AAP, the child should be reevaluated with a repeat urine culture and renal/bladder ultrasonography if clinical improvement does not occur within two days.[23]

The authors of randomized trials[35,36] comparing oral and parenteral regimens in children with fever and

positive urine cultures did not find differences in cure rates or speed of improvement. Parenteral antibiotics may be necessary if vomiting precludes oral administration.

The optimal duration of antibiotic therapy has not been established. One-day courses of antibiotics are less effective than longer courses.[37] Systematic reviews[37-39] of randomized trials comparing shorter and longer courses of antibiotics have had varying results, based in part on the inclusion of one-day courses in the analysis. Short courses (three to five days) of antibiotics may be as effective as longer courses (seven to 14 days), but this has not been clearly proved.[37-39]

No evidence was found to support a recommendation for routine posttreatment urine cultures in children with UTIs. In one study[40] of 364 children hospitalized with UTI, 291 (80 percent) had follow-up urine cultures, none of which was positive.

Prevention

In a one-year longitudinal study,[41] recurrent symptomatic UTI occurred in 12 percent of children younger than five years presenting to an emergency department with a first UTI. Children younger than six months had a higher risk of recurrence (18.6 percent).

Prophylactic antibiotics may reduce the risk of recurrent UTI. Two systematic reviews[42,43] found weak evidence of benefit with poor quality trials. Table 3[23] describes potential prophylactic regimens in children younger than two years. Only one comparison trial of antibiotic selection was found. In this six-month trial,[44] nitrofurantoin (Furadantin) was more effective than trimethoprim (Primsol) in preventing UTIs (number needed to treat [NNT] = 5.4) but was more likely to be discontinued because of side effects (number needed to treat to harm = 5.3), which were mainly gastrointestinal.

TABLE 2
Empiric Oral Antibiotic Therapy for UTI in Children

Antibiotic	*Daily dosage*
Amoxicillin	20 to 40 mg per kg in three doses*
Cefixime (Suprax)	8 mg per kg in two doses
Cefpodoxime (Vantin)	10 mg per kg in two doses
Cefprozil (Cefzil)	30 mg per kg in two doses
Cephalexin (Keflex)	50 to 100 mg per kg in four doses
Loracarbef (Lorabid)	15 to 30 mg per kg in two doses
Sulfisoxazole (Gantrisin)	120 to 150 mg per kg in four doses
Trimethoprim/sulfamethoxazole (Bactrim, Septra)	6 to 12 mg per kg/30 to 60 mg per kg in two doses

UTI = urinary tract infection.

**—Amoxicillin is the first choice for infants younger than two months.*

Adapted with permission from 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 [published corrections appear in Pediatrics 2000;105:141, 1999;103:1052, and 1999;104:118]. Pediatrics 1999;103:848.

Because VUR has been considered a predisposing factor to UTI and its complications, treatments for children with VUR have been promoted. Medical management often has used prophylactic antibiotics, but the systematic reviews[43] suggesting that prophylactic antibiotics prevent recurrent UTI did not include studies of children with VUR. Nonetheless, the AAP recommends prophylaxis until imaging studies are completed and until additional treatment based on the imaging findings is instituted.[23] Two systematic reviews[45,46] of randomized trials comparing surgical and medical management of VUR found no significant differences in UTI recurrence rates, renal function, renal scarring, hypertension, or end-stage renal disease. In two randomized trials[47,48] involving more than 400 children younger than 11 years who had grade III or IV VUR and documented UTI, surgery reduced the rate of acute pyelonephritis (21 to 22 percent incidence with surgery versus 8 to 10 percent with antibiotic prophylaxis alone; NNT = 7 to 9), but overall rates of UTI did not differ. A new treatment for children with VUR, dextranomer/hyaluronic acid

The Authors

BRIAN S. ALPER, M.D., M.S.P.H., is a research assistant professor in the Department of Family and Community Medicine at the University of Missouri–Columbia School of Medicine. Dr. Alper also is editor-in-chief of DynaMed. Dr. Alper received his medical degree from the Hahnemann University School of Medicine, Philadelphia. He completed a family medicine residency at Pennsylvania State University/Good Samaritan Hospital in Lebanon, and a family medicine faculty development fellowship at the University of Missouri–Columbia.

SARAH H. CURRY, M.D., is a resident in the University of Missouri–Columbia Family and Community Medicine residency program. Dr. Curry received her medical degree from the University of Missouri–Columbia School of Medicine.

Address correspondence to Brian S. Alper, M.D., M.S.P.H., DynaMed LLC, 10 Estes St., Ipswich, MA 01938 (e-mail: editor@dynamicmedical.com). Reprints are not available from the authors.

TABLE 3
Antibiotic Choices for UTI Prophylaxis in Children

Antibiotic	*Dosage*
Methenamine mandelate (Mandelamine)	75 mg per kg per day in two doses
Nalidixic acid (NegGram)	30 mg per kg per day in two doses
Nitrofurantoin (Furadantin)	1 to 2 mg per kg once per day
Sulfisoxazole (Gantrisin)	10 to 20 mg per kg per day in two doses
Trimethoprim/sulfamethoxazole (Bactrim, Septra)	2 mg per kg/10 mg per kg nightly *or* 5 mg per kg/25 mg per kg twice per week

UTI = urinary tract infection.

Adapted with permission from 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 [published corrections appear in Pediatrics 2000;105:141, 1999;103:1052, and 1999;104:118]. Pediatrics 1999;103:849.

copolymer (Deflux), is a bulking agent placed endoscopically near the distal ureteral orifice. Deflux was more effective than antibiotic prophylaxis in resolving childhood VUR in one randomized trial[49] of 61 children but did not prevent UTI. Nine UTIs were recorded in six of the 40 children in the Deflux group, whereas none occurred in the 21 children receiving antibiotics.[49]

Cranberry juice and related products have not been shown to prevent or reduce UTI in children; in a systematic review[50] of seven trials, the evidence base was too limited to support such conclusions.

Circumcision prevented recurrent symptomatic UTI in one randomized trial.[51] Seventy uncircumcised boys three months to 10 years of age with a first symptomatic culture-confirmed UTI were randomized to immediate circumcision or circumcision after six months. Recurrent symptomatic UTIs developed in three of 35 boys during the six-month delay (8.6 percent) but not in the boys who received immediate circumcision (NNT = 12). Circumcision may provide primary prevention of UTI in boys, based on prospective follow-up of 69,100 boys for two to three years.[52] However, circumcision may not be warranted for this specific purpose because 195 circumcisions would be needed to prevent one hospital admission for UTI in the first year of life.

Data sources: Online sources including PubMed, The Cochrane Library, Clinical Evidence, DynaMed, and the National Guideline Clearinghouse were searched in April 2003 using "urinary tract infection" and age limitations (younger than 18 years) where applicable. Reference lists of retrieved articles and reviews also were used. The highest level of evidence found for each specific topic was included. This review is based on a more thorough version of this topic that is available in DynaMed (http://www.DynamicMedical.com) and is updated as additional relevant information is identified.[53]

The authors would like to thank J. Lynn Teague, M.D., F.A.A.P., Associate Professor of Clinical Surgery, Urology and Child Health, University of Missouri–Columbia, for clinical and editorial feedback and for providing expert recommendations.

Author disclosure: Dr. Alper is editor-in-chief of DynaMed.

REFERENCES

1. Marild S, Jodal U. Incidence rate of first-time symptomatic urinary tract infection in children under 6 years of age. Acta Paediatr 1998;87:549-52.
2. Bachur R, Harper MB. Reliability of the urinalysis for predicting urinary tract infections in young febrile children. Arch Pediatr Adolesc Med 2001;155:60-5.
3. Twaij M. Urinary tract infection in children: a review of its pathogenesis and risk factors. J R Soc Health 2000;120:220-6.
4. Loening-Baucke V. Urinary incontinence and urinary tract infection and their resolution with treatment of chronic constipation of childhood. Pediatrics 1997;100:228-32.
5. Koff SA, Wagner TT, Jayanthi VR. The relationship among dysfunctional elimination syndromes, primary vesicoureteral reflux and urinary tract infections in children. J Urol 1998;160:1019-22.
6. Shaikh N, Hoberman A, Wise B, Kurs-Lasky M, Kearney D, Naylor S, et al. Dysfunctional elimination syndrome: is it related to urinary tract infection or vesicoureteral reflux diagnosed early in life? Pediatrics 2003;112:1134-7.
7. Struthers S, Scanlon J, Parker K, Goddard J, Hallett R. Parental reporting of smelly urine and urinary tract infection. Arch Dis Child 2003;88:250-2.
8. Labbe J. Self-induced urinary tract infection in school-age boys. Pediatrics 1990;86:703-6.
9. Hellerstein S. Recurrent urinary tract infections in children. Pediatr Infect Dis 1982;1:271-81.
10. Pollack CV Jr, Pollack ES, Andrew ME. Suprapubic bladder aspiration versus urethral catheterization in ill infants: success, efficiency and complication rates. Ann Emerg Med 1994;23:225-30.
11. Liaw LC, Nayar DM, Pedler SJ, Coulthard MG. Home collection of urine for culture from infants by three methods: survey of parents' preferences and bacterial contamination rates. BMJ 2000;320:1312-3.
12. Ramage IJ, Chapman JP, Hollman AS, Elabassi M, McColl JH, Beattie TJ. Accuracy of clean-catch urine collection in infancy. J Pediatr 1999;135:765-7.
13. Bulloch B, Bausher JC, Pomerantz WJ, Connors JM, Mahabee-Gittens M, Dowd MD. Can urine clarity exclude the diagnosis of urinary tract infection? Pediatrics 2000;106:E60.
14. Gorelick MH, Shaw KN. Screening tests for urinary tract infection in children: a meta-analysis. Pediatrics 1999;104:E54.

15. Rawal K, Senguttuvan P, Morris M, Chantler C, Simmons NA. Significance of crystal clear urine. Lancet 1990;335:1228.
16. Tremblay S, Labbe J. Crystal-clear urine and infection. Lancet 1994;343: 479-80.
17. Huicho L, Campos-Sanchez M, Alamo C. Metaanalysis of urine screening tests for determining the risk of urinary tract infection in children. Pediatr Infect Dis J 2002;21:1-11.
18. Hoberman A, Chao HP, Keller DM, Hickey R, Davis HW, Ellis D. Prevalence of urinary tract infection in febrile infants. J Pediatr 1993;123:17-23.
19. Crain EF, Gershel JC. Urinary tract infections in febrile infants younger than 8 weeks of age. Pediatrics 1990;86:363-7.
20. Shaw KN, McGowan KL, Gorelick MH, Schwartz JS. Screening for urinary tract infection in infants in the emergency department: which test is best? Pediatrics 1998;101:E1.
21. Pitetti RD, Choi S. Utility of blood cultures in febrile children with UTI. Am J Emerg Med 2002;20:271-4.
22. Bachur R, Caputo GL. Bacteremia and meningitis among infants with urinary tract infections. Pediatr Emerg Care 1995;11:280-4.
23. 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. [published corrections appear in Pediatrics 2000;105:141, 1999;103:1052, and 1999;104:118]. Pediatrics 1999;103:843-52.
24. Zamir G, Sakran W, Horowitz Y, Koren A, Miron D. Urinary tract infection: is there a need for routine renal ultrasonography? Arch Dis Child 2004;89:466-8.
25. Dick PT, Feldman W. Routine diagnostic imaging for childhood urinary tract infections: a systematic overview. J Pediatr 1996;128:15-22.
26. Dick PT. Annual Meeting of Canadian Pediatric Society, June 12-16, 2002. Pediatric Notes 2002;26(27):105.
27. Hoberman A, Charron M, Hickey RW, Baskin M, Kearney DH, Wald ER. Imaging studies after a first febrile urinary tract infection in young children. N Engl J Med 2003;348:195-202.
28. Smellie JM, Prescod NP, Shaw PJ, Risdon RA, Bryant TN. Childhood reflux and urinary infection: a follow-up of 10-41 years in 226 adults. Pediatr Nephrol 1998;12:727-36.
29. Jacobson SH, Eklof O, Eriksson CG, Lins LE, Tidgren B, Winberg J. Development of hypertension and uraemia after pyelonephritis in childhood: 27 year follow up. BMJ 1989;299:703-6.
30. Nuutinen M, Uhari M. Recurrence and follow-up after urinary tract infection under the age of 1 year. Pediatr Nephrol 2001;16:69-72.
31. Hellerstein S, Nickell E. Prophylactic antibiotics in children at risk for urinary tract infection. Pediatr Nephrol 2002;17:506-10.
32. Wennerstrom M, Hansson S, Jodal U, Stokland E. Primary and acquired renal scarring in boys and girls with urinary tract infection. J Pediatr 2000;136:30-4.
33. Rushton HG, Majd M, Jantausch B, Wiedermann BL, Belman AB. Renal scarring following reflux and nonreflux pyelonephritis in children: evaluation with 99mtechnetium-dimercaptosuccinic acid scintigraphy [published correction appears in J Urol 1992;148:898]. J Urol 1992;147:1327-32.
34. Martinell J, Claesson I, Lidin-Janson G, Jodal U. Urinary infection, reflux and renal scarring in females continuously followed for 13-38 years. Pediatr Nephrol 1995;9:131-6.
35. Hoberman A, Wald ER, Hickey RW, Baskin M, Charron M, Majd M, et al. Oral versus initial intravenous therapy for urinary tract infections in young febrile children. Pediatrics 1999;104:79-86.
36. Baker PC, Nelson DS, Schunk JE. The addition of ceftriaxone to oral therapy does not improve outcome in febrile children with urinary tract infections. Arch Pediatr Adolesc Med 2001;155:135-9.
37. Keren R, Chan E. A meta-analysis of randomized, controlled trials comparing short- and long-course antibiotic therapy for urinary tract infections in children. Pediatrics 2002;109:E70.
38. Michael M, Hodson EM, Craig JC, Martin S, Moyer VA. Short versus standard duration oral antibiotic therapy for acute urinary tract infection in children. Cochrane Database Syst Rev 2004;(4):CD003966.
39. Tran D, Muchant DG, Aronoff SC. Short-course versus conventional length antimicrobial therapy for uncomplicated lower urinary tract infections in children: a meta-analysis of 1279 patients. J Pediatr 2001;139:93-9.
40. Currie ML, Mitz L, Raasch CS, Greenbaum LA. Follow-up urine cultures and fever in children with urinary tract infection. Arch Pediatr Adolesc Med 2003;157:1237-40.
41. Panaretto K, Craig J, Knight J, Howman-Giles R, Sureshkumar P, Roy L. Risk factors for recurrent urinary tract infection in preschool children. J Paediatr Child Health 1999;35:454-9.
42. Williams GJ, Lee A, Craig JC. Long-term antibiotics for preventing recurrent urinary tract infection in children. Cochrane Database Syst Rev 2004;(4):CD001534.
43. Le Saux N, Pham B, Moher D. Evaluating the benefits of antimicrobial prophylaxis to prevent urinary tract infections in children: a systematic review. CMAJ 2000;163:523-9.
44. Brendstrup L, Hjelt K, Petersen KE, Petersen S, Andersen EA, Daugbjerg PS, et al. Nitrofurantoin versus trimethoprim prophylaxis in recurrent urinary tract infection in children. A randomized, double-blind study. Acta Paediatr Scand 1990;79:1225-34.
45. Jodal U, Hansson S, Hjalmas K. Medical or surgical management for children with vesico-ureteral reflux? Acta Paediatr Suppl 1999;88: 53-61.
46. Shanon A, Feldman W. Methodologic limitations in the literature on vesicoureteral reflux: a critical review. J Pediatr 1990;117:171-8.
47. Jodal U, Koskimies O, Hanson E, Lohr G, Olbing H, Smellie J, et al. Infection pattern in children with vesicoureteral reflux randomly allocated to operation or long-term antibacterial prophylaxis. The International Reflux Study in Children. J Urol 1992;148:1650-2.
48. Weiss R, Duckett J, Spitzer A. Results of a randomized clinical trial of medical versus surgical management of infants and children with grades III and IV primary vesicoureteral reflux (United States). The International Reflux Study in Children. J Urol 1992;148:1667-73.
49. Capozza N, Caione P. Dextranomer/hyaluronic acid copolymer implantation for vesico-ureteral reflux: a randomized comparison with antibiotic prophylaxis. J Pediatr 2002;140:230-4.
50. Jepson RG, Mihaljevic L, Craig J. Cranberries for preventing urinary tract infections. Cochrane Database Syst Rev 2004;(4):CD001321.
51. Nayir A. Circumcision for the prevention of significant bacteriuria in boys [published correction appears in Pediatr Nephrol 2002;17:307]. Pediatr Nephrol 2001;16:1129-34.
52. To T, Agha M, Dick PT, Feldman W. Cohort study on circumcision of newborn boys and subsequent risk of urinary-tract infection. Lancet 1998;352:1813-6.
53. Alper BS, Teague JL. Urinary tract infection (UTI) in children. DynaMed. Last reviewed September 6, 2005. Accessed online September 15, 2005, at: http://www.DynamicMedical.com.