

PROBLEM URINARY TRACT INFECTIONS

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Bacterial urinary tract infection (UTI) occurs in approximately 14% of dogs in their lifetime, with a variable age of onset. Animals with a UTI can present with stranguria, pollakiuria, dysuria and urinary incontinence, although some animals may have no clinical signs. Spayed female dogs are at increased risk for a UTI, which is likely due to anatomic differences as well as possible protective secretions from the prostate in sexually-intact males. Urinary tract infection (UTI) occurs when bacteria colonize portions of the urinary tract that are normally sterile (i.e., kidney, ureter, bladder, and proximal urethra). Ascent of bacteria is the most common origin of bacteria in UTI. Fecal flora from the patient contaminate the perineum, ascend the urethra, and enter the bladder. Organisms that successfully gain entry into the bladder then have the potential to ascend the ureters, cross the renal pelvic epithelium, and enter renal parenchymal tissue. Vaginal, preputial, and distal urethral flora occasionally are the source of ascending bacteria. Ascending organisms can also come from the environment including that from hospital flora. Introduction of normal flora during catheterization and contamination with fecal or hospital flora also is possible. Migration of bacteria around an indwelling urinary catheter or through the catheter lumen occurs at times.

The urinary tract is exquisitely resistant to bacterial colonization during health. UTI results from abrogation of one or more natural defense mechanisms that allow bacteria to ascend from the perineum to the urethra, and then to the bladder. The development of a UTI means that the host defenses were overwhelmed at least transiently in order for UTI to develop. In order for UTI to develop, the animal must be exposed to uropathogenic bacteria in sufficient numbers, the animal must have epithelial receptors for uropathogens, and often suboptimal urinary defenses exist. Failure of normal urinary defenses include the possibilities of reduced anti-adherence properties of the uroepithelium, decreased antibacterial properties of urine, abnormal patterns of voiding, reduced integrity of intrinsic mucosal defenses, and presence of anatomic abnormalities.

Increased risk for the development of UTI occurs in dogs with anatomic abnormalities of the genitourinary system such as urachal remnants, ectopic ureters, excessive perivulvar skin folds/pyoderma (especially in recurrent UTI), or possibly vestibulovaginal stenosis. Exogenous steroid use in dogs, endogenous hyperadrenocorticism, and diabetes mellitus all add risk for development of UTI in dogs. Urolithiasis can be the result of UTI (struvite stones in dogs) or the stones may compromise the urinary defense systems. Urethrostomy, indwelling urinary catheterization, and single passage of a urinary catheter increase the risk that UTI will be acquired in dogs and cats. UTI occurs in approximately 30% of all cats with chronic renal failure (CRF), many within one year of diagnosis of CRF. Cats over 10 years of age that present for signs of lower urinary tract distress (LUTD) commonly have bacterial urinary infections, unlike young cats presenting with LUTD signs. Dogs with urinary incontinence may be at increased risk for development of UTI possibly due to the “wicking” action of urine that may allow ascent of bacterial organisms.

The definitive diagnosis of UTI requires confirmation from results of quantitative culture (cfu/ml) as the gold standard. The higher the quantity of organisms isolated from a properly collected and handled sample the greater the likelihood that a true UTI exists. See Table 1 for guidelines to help differentiate contamination from true UTI following isolation of organism from urine culture.

Table 1. Likelihood for diagnosis of a true bacterial UTI based on quantitative growth (cfu/ml) and the method of urine collection.

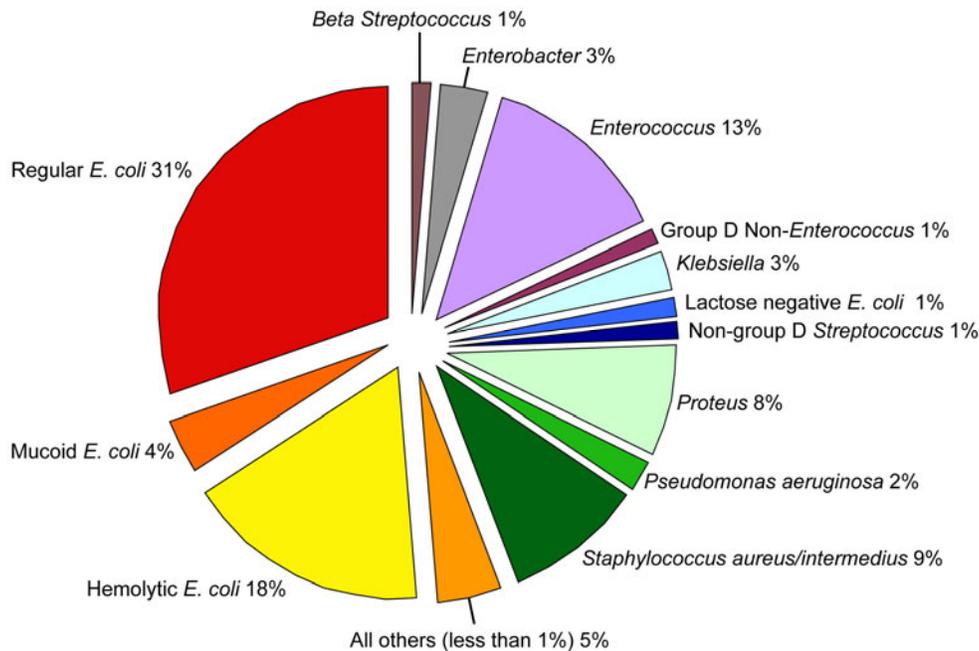
Culture method	Contamination (cfu/ml)	Infection (cfu/ml)
Midstream voided	< 10 ⁵	> 10 ⁵ in cats; cannot distinguish in dogs
Catheterized	< 10 ³ in male dogs and all cats; any number in female dogs	> 10 ⁴ in male dogs > 10 ³ in cats Any number in animals with indwelling catheters
Cystocentesis	< 10 ³ (be skeptical)	> 10 ³

Table adapted from Greene *et al.* Infectious Diseases of the Dog and Cat, 2006. p. 946

While a urine culture is the gold standard for diagnosis of a UTI, it can be costly, and in practice culture kits have been marketed for companion animal use. The Uricult® Vet paddles were reported at the ACVIM 2012 Forum to be a useful screening tool for identification of bacterial growth. Quantitative results (cfu/ml) determined by comparing growth on the paddles to a standard illustration of organism density provided by the manufacturer was not always accurate. Inaccuracy in identification of isolated organisms sometimes occurred when paddles were used, particularly when multiple uropathogens were present. This paddle system provides no method for susceptibility testing for isolated organisms, though they can be categorized into Gram-positive or Gram-negative status. When growth occurs, paddles or urine should be submitted to a commercial microbiology laboratory for identification and antimicrobial susceptibility testing. It should be determined if your referral microbiology laboratory will accept organisms already growing on paddles for definitive identification and MIC testing. This paddle system for organism isolation appears most clinically useful as an in-house method to identify urine samples that are sterile or those with low quantitative growth compatible with contamination during the sample collection.

Uncomplicated, community- acquired UTIs in dogs generally occur in healthy dogs and the most common urinary pathogen has been reported to be strains of *E. coli*, accounting for up approximately 45% of all pathogens isolated in one study (Ling 2001). When added together, *Staphylococcus*, *Proteus*, *Klebsiella* and *Enterococcus* spp. account for approximately an additional 40% of all isolates examined in that same study. Figure 1 shows the distribution of uropathogens typically isolated from veterinary microbiology laboratories.

Figure 1. Bacteria Associated with UTI in Dogs – 2000 to 2007. Courtesy of the Microbiology Laboratory of The Ohio State University College of Veterinary Medicine. (Drawn by Tim Vojt—From *Canine and Feline Nephrology and Urology*, edited by Chew DJ, DiBartola SP and Schenck PA; Elsevier 2010)



In order to help prevent *E. coli* and other pathogens from entering the urinary tract, several built in host “defense mechanisms” are present. Micturition itself and frequent and complete voiding can help remove bacteria. In addition to anatomic structures and urine voiding, the mucosal surface of the urinary tract has intrinsic mucosal antimicrobial properties and the glycosaminoglycan layer can also act as a protective mechanism. High urine osmolality and high concentrations of urea can also inhibit bacterial growth. While dilute (<1.018) urine may predispose an animal to bacterial infection, it is likely the disease that produces the dilute urine allows the infections to happen. In dogs, submitting a urine culture based on a low urine specific gravity (<1.013) does not appear to be cost-effective in the absence of active urine sediment or high clinical suspicion for UTI (Tivapasi 2009).

The likelihood for success or failure in long-term eradication of bacterial UTI involves interactions between the uropathogen, predisposing factors within the patient (functional, anatomical/structural, metabolic), and decisions made by the attending clinician and the owner regarding diagnostic evaluation and therapy. Urinary antibacterials remain the hallmark for treatment of UTI, though correction of predisposing factors is also important. The concentration of antimicrobial that is achieved in the urine (micrograms/mL) is the most important factor in predicting eradication of UTI. Tissue levels of the antimicrobial will be important in those with renal and prostatic infections, as well as those with markedly thickened bladder walls from chronic infection. Choosing an antimicrobial that exceeds the MIC for the infecting bacteria by at least fourfold is usually recommended. If the average urine concentration is four times the MIC value or higher, it is likely that the drug will be at least 90% effective in eradicating the offending organism in an otherwise healthy patient. Attainable urine concentrations of some antimicrobials can achieve up to 100 times that

attained in serum. Consequently, sterility within the urinary tract can be achieved at times when it would otherwise appear that these drugs would fail to do so at concentrations achieved in the plasma.

Antibacterial treatment for UTI is usually given for 7 to 14 days in those with uncomplicated UTI, at least 30 to 60 days for those with upper UTI, and for at least one month to sexually intact males. These guidelines for duration of treatment are based on conventional experience over the years, but surprisingly little data exist to support or refute these protocols. A new regimen for treatment of uncomplicated UTI in dogs using high doses of enrofloxacin for 3 days is described below. Ultimately, antimicrobials should be given for as long as is necessary to effect a bacteriologically sterile urine during administration of the medication and for a protracted time following discontinuation of the treatment. Antibacterials should be selected after confirmation of UTI by quantitative urinary culture. UTI can be treated on the basis of susceptibility testing, or on the basis of predicted biologic behavior in those with uncomplicated UTI.

Most UTI can be successfully sterilized via the oral route using penicillins (especially those with clavulanate), trimethoprim-potentiated sulfonamides, ormetoprim-potentiated sulfonamides, or first generation cephalosporins such as cephalexin or cefadroxil. Side effects associated with trimethoprim-potentiated sulfonamides include keratoconjunctivitis sicca, cytopenia, hepatopathy, and immune-mediated polyarthritis. Ormetoprim-potentiated sulfonamides are not effective in prostatic UTI. Trimethoprim-potentiated sulfonamides should be used in these cases. Sulfonamides of any kind should not be prescribed for those in which medical calculolytic protocols are in place. Sulfa can precipitate on the surface of the stone and either stop or dramatically decrease the rate of stone dissolution.

Fluoroquinolones such as norfloxacin, ciprofloxacin, enrofloxacin, orbifloxacin, marbofloxacin, and difloxacin provide oral treatment for resistant bacteria. The quinolones have a wide spectrum of antibacterial activity (except against enterococci and anaerobes), achieve high tissue concentrations, and are kidney-friendly. Difloxacin undergoes more hepatic excretion than the other fluoroquinolones, consequently less is excreted into urine. Fluoroquinolones should not be given to dogs that are still growing (less than 6 to 18 months of age depending on size/breed), due to the potential damaging effects on articular cartilage. The quinolones should be reserved for treatment when other therapeutic agents have failed unless there is compelling evidence that the organism in question is highly resistant to other antibacterial agents. An association between the use of enrofloxacin and blindness in some cats has been reported, with mydriasis often an early finding. All fluoroquinolones can create retinal lesions at higher doses. Although retinal toxicity is noted to be idiosyncratic in some cats, cats with renal or liver disease are at increased risk for toxicity, as reduced metabolism will result in higher plasma levels of fluoroquinolones and their metabolites. Reports of blindness in cats treated with enrofloxacin have decreased dramatically since the flexible dose range was redefined. A dose of 3 mg/kg once daily or 2.5 mg/kg twice daily is recommended in cats with renal or liver disease. IV fluoroquinolones should not be used in cats with liver or renal disease.

In a recent prospective clinical study, treatment of uncomplicated bacterial UTI in dogs was compared between a high-dose short duration (HDSD) course of enrofloxacin and a standard duration regimen of amoxicillin-clavulanate (Westropp JVIM 2012). Dogs were excluded from the study if they had a history of persistent or recurrent UTI, defined as > 3 UTIs in 1 year with or without a period of sterility; uncontrolled comorbid diseases or

concurrent urinary problems such as calculi or neoplasia; furthermore those dogs recently receiving antimicrobials or glucocorticosteroids were not eligible. Dogs were randomized into one of two groups. Dogs in Group 1 received enrofloxacin at 18-20mg/kg orally once daily for 3 consecutive days and those in Group 2 received amoxicillin-clavulante at 13.75-25mg/kg orally twice daily for 14 days. Both treatment groups had urinalyses and urine cultures submitted on day 0, 10, and 21. The microbiologic and clinical cure rates were compared between groups seven days after completing the antimicrobial regimen (day 10 for Group 1 and day 21 for Group 2). There were 35 dogs in group 1 and 33 in group 2. The microbiologic cure rate was 77.1 and 81.2% for groups 1 and 2, respectively. The clinical cure rate was 88.6 and 87.9% for groups 1 and 2, respectively. Cure rates between groups did not differ according to the selected margin of noninferiority. HDS enrofloxacin treatment was not inferior to a conventional amoxicillin-clavulanic acid protocol for the treatment of uncomplicated bacterial UTI in dogs. These data suggest that the HDS enrofloxacin protocol was similarly effective to the standard protocol of 14 days of treatment with amoxicillin-clavulanate in treating uncomplicated canine UTI in this sample patient population and may represent a viable alternative therapeutic regimen for similar patients. Further research is warranted to determine if this protocol will positively impact owner compliance and decrease the emergence of antimicrobial resistance in fecal flora or in organisms associated with relapsing UTI.

In another study, urinary levels of enrofloxacin and ciprofloxacin were measured at 2, 8 and 24 hours in 6 normal dogs following administration of enrofloxacin at 20 mg/kg as a single oral dose. The urinary concentration of enrofloxacin at 8 hours post administration was approximately 70 to 165 ug/ml and from 195 to 435 ug/ml for ciprofloxacin at the same time (From S OSU Master's 2010). The package insert label for Baytril® reports urinary levels of enrofloxacin at 43 ug/ml at 2 hours and at 55 ug/ml at 8 hours following a single oral dose at 2.5 mg/kg in the 2 dogs reported. The insert label does not report the levels of ciprofloxacin achieved. It appears that a single dose of enrofloxacin at 20 mg/kg achieves high levels of urinary enrofloxacin and even higher levels of ciprofloxacin. Future decision making for likely urinary susceptibility to enrofloxacin should take into account the high levels of urinary ciprofloxacin generated following metabolism of enrofloxacin in addition to that of enrofloxacin. The use of ciprofloxacin in dogs is not recommended due to the low bioavailability of this drug in canine patients.

Those that fail to get better (reduction in signs, pyuria, and quantitative urine culture results) or have multiple new positive cultures (with or without clinical signs) are by definition "difficult". Animals that have received antibacterial treatment within the past two months are at increased risk that the organisms causing their UTI will be more resistant than from those who have not recently been exposed to antibiotics. Complicated cases have identifiable defects in host defense mechanisms, including anatomical, functional, or metabolic defects. They may have mucosal damage due to urolithiasis or neoplasia, alteration in urine volume or composition, be affected by a concurrent systemic disorder (diabetes mellitus, hyperadrenocorticism, neoplasia), or have received long-term exogenous steroids.

Recurrent infections are repeated episodes of bacterial urinary infection (positive quantitative urine culture often associated with clinical signs) usually following therapy. Recurrent infections are reinfections, relapsing infections, or persistent infections. Since treatment is so different, it is important to distinguish between recurrent infection that is due to reinfection, relapsing, or persistent infection. The only reliable way to do this is with

quantitative urine cultures that are taken before treatment, while on antibacterials, and at various time intervals after treatment has been discontinued. Imaging studies are important in the evaluation of recurrent UTI (radiographs, contrast urography, ultrasonography, cystoscopy).

Reinfection is another clinical episode caused by a different organism than previously involved. This organism may be an entirely different genus and species, or may be the same, but a different biotype (54% of recurrent UTI). This is a new infection that classically occurs weeks to months following discontinuation of drug therapy for a previous UTI. Multiple new infections suggest that the animal's host defense mechanisms are not operating properly. A search for predisposing factors should be undertaken which includes anatomical defects, urolithiasis, urine retention (neurologic dysfunction), and neoplasia with disruption of urothelium.

No predisposing factors were found in 30% of dogs with recurrent UTI in one study, (Seguin, et al 2003) indicating primary failure of defense mechanisms. Predisposing factors for recurrent UTI were identified in 70% of these dogs of which about 1/3 could be corrected. Nearly 30% of the isolates from this study were resistant to achievable plasma concentrations of commonly prescribed oral antibacterials.

In some instances, dogs with reinfections will have moderate to severe recession of the vulva due to overlying skin folds or cranial displacement of the vulva. It appears that this type of vulvar recession is a risk factor in dogs prone to UTI (many without UTI also have vulvar recession). The flora and or number of organisms near the vulva likely favors increased ascent of bacteria; the recessed vulva may also serve as a barrier to the complete emptying of urine which can contribute to incontinence or ascending infection due to wicking of bacteria. Recent reports attest to the success of vulvoplasty or episoplasty in dramatically reducing the recurrence of UTI in these individuals. This risk factor is frequently overlooked by primary care veterinarians and also internists and surgeons.

The syndrome of so-called "vestibulo-vaginal stenosis" has been implicated as an underlying cause for recurrent UTI and urinary incontinence. We remain skeptical about the reality of this diagnosis, as we have failed to confirm this condition during cystoscopy in hundreds of female dogs with a variety of lower urinary tract conditions. There is tremendous variation in the normal diameter of the vestibulo-vaginal junction – varying with sexual status and the conditions of vaginography. Digital palpation of the vestibule is not reliable to establish this diagnosis. Studies employing CT vaginography and cystoscopy to make precise measurements indicate wide variability in the normal appearance and measurement of these structures (Wangs and Samii). We advise caution in the use of any aggressive surgical correction of vestibulo-vaginal stenosis. It is our opinion that vestibulo-vaginal stenosis is over diagnosed in the referral community.

Relapsing infection is another clinical episode caused by the same identical organism (same serotype) and implies persistence of an organism that was never eradicated (44% of recurrent UTI). This suggests that the infection is deep-seated within the tissues or that the organisms are resistant to the chosen antibacterial. Clinical signs tend to occur soon following discontinuation of medications, usually within days to a week.

Persistent UTI is a variant of relapsing infection in which bacterial cultures remain positive with the same organism during antibacterial treatment. In this instance it has never been possible to eradicate the organism even transiently. Persistent infection occurs in approximately 2% of all recurrent UTI and implies severe abrogation of local host defenses,

or that the organism is highly resistant to the present antimicrobial agent. A search for predisposing factors should be undertaken to exclude pyelonephritis and obstructive nephropathy, urolithiasis, chronic bladder wall changes allowing sequestration of bacteria anatomical defects, polypoid cystitis, urine retention, and prostatic or uterine reinoculation from bacterial prostatitis or metritis.

Female dogs typically have recurrent infections with Staphylococcus, Enterococcus sp., or Pseudomonas. Male dogs with recurrent UTI are more likely to have Klebsiella, Providencia, Salmonella sp., Corynebacterium sp., Acinetobacter sp., and Actinomyces sp. In recurrent infections, 20% of dogs have two bacterial organisms isolated, and 4% have three isolated.

Long-term medication is not usually indicated for those with reinfection forms of UTI, since routine therapy will eradicate the present infection. Most of the time, predisposing factors will not be found despite intensive investigation. The present infection is usually easily eradicated, but it often recurs in subsequent months. The organisms associated with reinfections are not usually those with high resistance patterns to urinary antibacterials. Though no studies have been reported on the effectiveness of these protocols, prophylactic therapy can be useful to prevent new infections after the previous infection has been sterilized in patients that have had multiple incidents of UTI. Sub-therapeutic doses of antimicrobials are given, but often successfully prevent the development of new UTI. This may allow the host's defense systems to handle reduced numbers of bacteria. Bacteria that are not directly killed by the antimicrobial may not express the fimbria necessary to attach to the urothelium, and consequently are readily flushed away during voiding. An appropriate antimicrobial is administered in the standard manner and then is followed by the chronic administration of 1/3 to 1/2 of the total daily dosage given once daily. It is recommended that the owner give the medication at bedtime. This maintains high levels of the excreted antimicrobial within the urine, obtaining a maximal prophylactic effect. Trimethoprim-potentiated sulfonamide, cephalexin, or nitrofurantoin is recommended if the UTI has a Gram-negative etiology. Ampicillin/clavulanate or trimethoprim-potentiated sulfonamide is effective when the UTI is associated with Gram-positive bacteria. Fluoroquinolones may be given for prophylaxis if the UTI has been associated with highly resistant organisms. It may be best to use the antibiotic for prophylaxis that most recently resulted in clearance of the UTI using full therapeutic doses. Prophylaxis may be necessary for at least six consecutive months to prevent reinfections. Ideally, the urine should be cultured monthly to ensure that the urine remains sterile. If the urine remains sterile for 6 months, the animal's urinary defense mechanisms may have improved, and further medication may no longer be needed.

By definition, relapsing UTI means that we have never fully eradicated the organism from the urinary tract, either because the organisms are inaccessible, not enough antimicrobial is concentrating in the urinary tract, or that the organisms are highly resistant to the chosen antibacterial. Long-term therapy with an appropriate antibiotic for 30 to 60 days or longer may be necessary. Susceptibility testing preferably with methods that report MIC should be performed to ensure selection of an antibiotic with a chance to eradicate the organism. Change of antibiotic class may be needed to one that achieves greater tissue penetration such as that which is achieved with the use of fluoroquinolones. It is essential to make sure that predisposing anatomical factors (urolithiasis, polypoid cystitis, urachal remnants) that allow sequestration of bacteria have been eliminated. Culture of urine while the animal is receiving antimicrobials is recommended as an in-vivo method of susceptibility

testing. There is no chance for bacterial eradication if organisms continue to grow in urine while being treated with antibacterials.

By definition, persistent UTI is associated with bacterial organisms that continue to grow in urine from patients that are receiving antibacterials. This is the worst case scenario of those with recurrent UTI. The fact that urine cannot be sterilized while on antibacterials indicates treatment failure. This occurs when the organisms are resistant to the chosen antibacterial, when the antibacterial does not accumulate in high enough concentration to inhibit the organism (such as in patients with reduced renal function), when the organisms are inaccessible, or when the host urinary defenses are severely compromised.

More potent antibacterials should be chosen if the organism is resistant to first line antibacterials initially or the MIC increases during treatment to levels beyond that than can be achieved by the present antibacterial. Antibiotics that have greater tissue penetration may be needed in those with chronic inflammatory and scarring changes of cystitis or pyelonephritis. Aminoglycosides (gentamicin, amikacin) should be reserved for highly resistant bacteria, or those that have failed to respond to aggressive treatment with other antibacterials. Aminoglycosides can be nephrotoxic, and are available only via injection. If needed, less nephrotoxicity is encountered if the daily dose is given all at once rather than divided throughout the day. Ceftiofur sodium is a third generation cephalosporin labeled for treatment of dogs with UTI and can be effective in the eradication of UTI when given by once daily injection. Ceftiofur has good activity against *E. coli* and *Proteus*, but possesses little activity against *Pseudomonas* or *Enterococcus*. Cefizime (Suprax® tablets & suspension) is a third generation oral cephalosporin that is useful for the treatment of resistant infections, but it is very expensive. Methenamine is an older antiseptic drug that can be useful in the treatment of *E. coli* UTI that is resistant to the fluoroquinolones. Methenamine is metabolized to formaldehyde which kills bacteria, but it requires highly acid urine for this effect. Meropenem and imipenem can be used for selected cases of UTI with highly resistant bacteria – they should not be used for routine UTI.

Successful treatment depends on the presence of sterile urine during and after medication. Resolution of clinical signs, hematuria, proteinuria, and microscopic bacteriuria can be misleading, since these can occur from reduced activity of the UTI, but not necessarily its eradication. Quantitative urine cultures are recommended 5 to 7 days, 1 month, and 3 months after medication has been discontinued to ensure that sterility within the urinary tract has been maintained. For recurrent cases of UTI, quantitative culture of urine during treatment can be quite helpful (See Tables).

Cranberry juice or extract may be effective to reduce the frequency of recurrent UTI due to new infections in some humans following initial eradication of UTI with antimicrobial drugs. This beneficial effect has been attributed to impairment of bacterial adherence to uroepithelium by proanthocyanidins (PAC) found in cranberries; this effect may be more specifically directed against attachment of P-fimbriated *E. coli* to uroepithelium. Adherence to uroepithelium is an initial first step in colonization and further growth resulting in the establishment of UTI. Anti-adherence properties against uropathogenic *E. coli* were demonstrated in two studies using urine from dogs treated with cranberry extract. Urine collected from female dogs treated for 30 days with cranberry extract showed a 30% decrease in adherence of *E. coli* using cell cultures from Madin-Darby Canine Kidney (MDCK) cells compared to urine before treatment (Smee JVIM 2011). Male dogs were treated daily for 3 weeks with cranberry extract in a second study using an assay designed to demonstrate the

ability of P-fimbriated *E.coli* to agglutinate human red blood cells. Anti-adhesion activity was demonstrated in the urine of these dogs within three hours following treatment with cranberry extract and the peak effect was reached by 7 days (Howell JVIM 2010). Both of these studies used surrogates for attachment of uropathogenic *E. coli* to uroepithelium in clinical patients. Studies demonstrating the ability of cranberry extract to reduce the frequency of recurrent UTI in dogs have yet to be published. Moreover, the degree to which uropathogenic *E.coli* contribute to the overall incidence of UTI in dogs is unknown, and the effect of cranberry therapy on pathogens lacking P-fimbriae (e.g. *Staphylococcus* spp., *Enterococcus* spp., *Proteus* spp.) is also unknown.

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Figure 1. Uropathogenic *Escherichia coli* and uroepithelial cell. Structure with pili, adhesins, and virulence factors. Adhesins on the end of the fimbria facilitate binding to specific receptors on the uroepithelial cells. 1, Supercoiled bacterial DNA; 2, Lipopolysaccharide (LPS) of bacterial wall; 3, 4, and 6, Fimbria without adhesins that fit into uroepithelial cells; 5. Fimbria with adhesins that specifically fit into the uroepithelial receptors-binding with these receptors is pivotal in allowing the establishment of UTI; 7, Flagellum; 8, Various virulence factors produced by the organisms that favor pathogenicity. (Drawn by Tim Vojt—From *Canine and Feline Nephrology and Urology*, edited by Chew DJ, DiBartola SP and Schenck PA; Elsevier 2010)

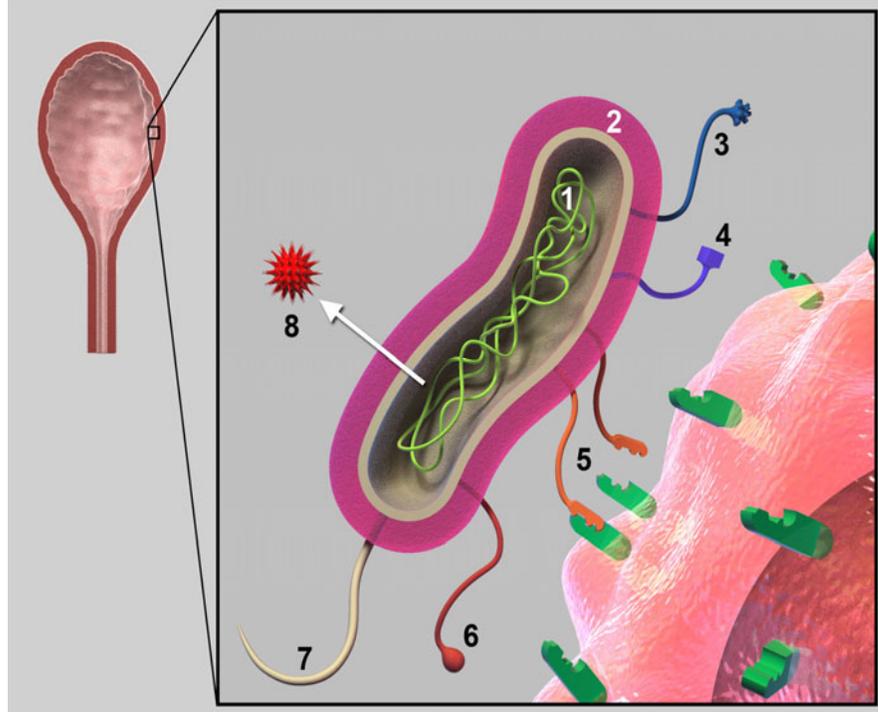


Table 1. Functional/Anatomical abnormalities predisposing to or perpetuating UTI

(Complicated UTI)

- Deep-seated cystitis (chronic wall changes)
- Pyelonephritis
- Prostatitis (sexually-intact)
- Metritis/pyometra
- Neoplasia – bladder/urethra
- Small urinary calculi – previously missed
- Urachal remnant (developmental)
- Peri-urachal microabscesses
- Ectopic ureters (developmental)
- Urethral sphincter incompetence with incontinence
- Polypoid cystitis
- Poor vulvar conformation/development
- Vestibulovaginal stenosis (developmental)
- Ureterocele
- Bladder atony (residual urine volume)
- Neurogenic bladder/urethra
- Detrusor-urethral dyssynergia
- Urethral stricture
- Urethral fistula or other anomalous pattern

Table 2. Metabolic conditions predisposing to or perpetuating UTI

- Diabetes mellitus
- Hyperadrenocorticism
- Exogenous steroid administration
- Renal Failure (especially cats)
- Hyperthyroidism
- Immunosuppression/chemotherapy

Table 4 . **Schedule of urine cultures for difficult recurrent cases.** Recheck cultures should never be taken by urinary catheter, as it is impossible to perform a sterile catheterization because of distal urethral flora and the propensity for vaginal contamination during this procedure.

Initially	Document organism and susceptibility
3 to 5 Days on Treatment	Document effective eradication in urine Rule out persistent infection Change in MIC if persistent? Rapid emergence of resistance?
3 days before treatment ends	Rule out superinfection – rare (new organisms identified?)
7 to 10 days after treatment ends	Rule out relapse
1, 2, 3, 6, 12 months after treatment	Identify reinfections