The clinical signs of a bacterial cystitis can include stranguria, pollakiuria, inappropriate urinations, dysuria and hematuria. Occult urinary tract infections (UTIs) in dogs and cats have also been reported.1, 2 Bacterial UTIs occur in approximately 14% of dogs in their lifetime,3 with a variable age of onset. Spayed female dogs have been reported to be at increased risk for a UTI, which is likely due to anatomic differences as well as possible protective secretions from the prostate.4 While UTIs are uncommon in younger cats, the prevalence increases with increasing age. It is reported from referral institutions that most young cats that present with LUTS do not have a positive urine culture,5 while older cats can have a positive culture as much as 15-20% of the time; concurrent illnesses such as diabetes mellitus, chronic kidney disease and hyperthyroidism are often present.6 A slight male predisposition has been reported in cats, which likely occurs because male cats can present with urethral obstruction and are more likely to be catheterized. In both species, other factors such as multiple urinary catheterizations, perineal or scrotal urethrostomies,7 a recessed vulva and perivulvar pyoderma,8 indwelling urinary catheter,9 or tube cystostomies10 predispose to colonization of bacteria in the lower urinary tract.

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 some have stated that dilute (<1.018) urine may predispose an animal to bacterial infection, we did not find any correlation between decreasing urine specific gravity and positive urine culture in cats.6 Similar findings have been found in preliminary studies from our lab in dogs. We are uncertain if it is the disease that causes the dilute or the dilute urine itself that is a predisposing factor for UTIs in small animals.

Physical Examination and Diagnostics

As mentioned previously, a UTI should be suspected in dogs that present with LUTS; urinary incontinence can also be a present in dogs with infection. Some dogs and cats can have bacterial cystitis without any apparent clinical signs. A thorough physical examination is important and special attention should be paid to the lower urinary tract. All dogs should have a rectal examination to evaluate the prostate for size, pain, and symmetry. The urethra should be palpated for irregularities, mass lesions or calculi. In female dogs the vulva should be examined to evaluate if it is recessed (“hooded”) and for the presence of urine leakage.

In all patients suspected of having a UTI, a urinalysis and bacterial culture provide the most diagnostic information. A quantitative urine culture obtained by cystocentesis is the gold standard for documenting a UTI. Free catch samples are generally of no diagnostic value unless the culture is negative. Ideally, the urine should be cultured within 30 minutes of collection; if this is not possible it should be refrigerated and then plated for culture within 6-8 hours of collection.11 If a UTI is present, pyuria, bacteruria, and hematuria can often be identified on the sediment examination. Although not specific for a UTI, these factors were all associated with positive urine culture outcome in cats2,6 and presumably dogs. The sediment is more reliable for evaluating these factors than the dipstrip; the nitrate and leukocyte assays are unreliable in dogs and cats.12
In most uncomplicated UTIs, a complete blood count (CBC) and biochemical profile is not warranted, as the results of these tests are usually normal. However, if recurrent bacterial cystitis has been documented or one suspects pyelonephritis or prostatitis, blood work should be evaluated because significant elevations in the white blood cell count, BUN and creatinine can be seen in these latter two conditions. Imaging studies such as radiographs and abdominal ultrasound would also be indicated if systemic organ involvement were suspected. Furthermore, if prostatitis is suspected, aspirates of the prostate can be obtained for cytology and culture.

**Treatment for Bacterial UTIs**

The first question the clinician must ask themselves prior to treating a dog or cat for a UTI is: should this patient be treated for this bacterial cystitis? If the dog or cat is exhibiting clinical signs treatment with the proper antimicrobials is warranted. Whether one should treat a dog or cat with “asymptomatic” (or occult) bacteruria has recently become more controversial. Overzealous use of antibiotics can lead to pathogens that are resistant and may not improve the outcome of the patient. In humans, the Infectious Diseases Society of America has published guidelines for treating asymptomatic bacteriuria in adults. In summary, if a human has a positive culture without clinical signs, s/he should be treated if certain surgical or interventional (cystoscopic) procedures are scheduled. Oftentimes, humans with asymptomatic bacteriuria associated with diabetes mellitus, spinal cord injuries, and older persons in resident communities are not treated as it does not appear to affect outcome and can lead to resistant strains of bacteria. For a complete list of their recommendations, the reader is referred to the literature.\(^\text{13}\)

In a study evaluating cats with occult bacterial urinary tract infections, phylogenetic analysis of the *E. coli* isolates confirmed that over ¾ of the isolates belonged to the phylogenetic group B2, suggesting the gram negative infections may not be benign and treatment may be warranted. However, some potential uropathogenic *E. coli* virulence genes have been reported in human cases of asymptomatic bacteriuria and are still left untreated. Clinical trials in humans have found no benefit treating for asymptomatic bacteriuria and negative outcomes have occurred with overzealous and misuse of antibiotics such as increased bacterial resistance.\(^\text{14}\)

Recommendations for occult UTIs in animals have not been formally investigated, but treating UTIs in animals that are undergoing surgery, laser lithotripsy or voiding urohydropropulsion seems prudent. The author does not always treat occult bacterial cystitis in dogs and cats with tube cystostomies, indwelling catheters, and chronic UTIs in patients with upper and lower motor neuron bladders, and otherwise healthy cats and dogs with no clinical signs of infection. Monitoring of these patients by evaluating renal parameters periodically is justified. Prospective studies in animals are needed to see if treatment, particularly for the latter disorders mentioned, affects clinical outcome and/or leads to bacterial resistance.

**Susceptibility Testing and Treatment**

**The MIC**

The MIC is the most widely used methodology and determines the least amount of an antimicrobial agent that causes the complete inhibition of growth of the infecting species or strain of bacteria. Current *in vitro* susceptibility testing is based on utilizing bacterial inoculums of \(10^5\) CFUs/ml. The average urine concentration of an antibiotic must exceed the growth-inhibiting concentration (MIC value) for the infecting bacteria by at least four fold. If the average urine concentration is greater than or equal to that of the MIC value x 4, the drug will be at least 90% effective.

Attainable urine concentrations of antimicrobials can be 100 times the attainable serum concentration. The clinician should consult the laboratory used to determine if serum
concentrations or urine concentrations of the antibiotics were used in the susceptibility testing for urinary bacterial isolates.

**The Mutant Prevention Concentration (MPC) and Mutant Selection Window (MSW)**

Resistance prevention is being investigated more frequently and this has led to more published research evaluating the mutant prevention concentration (MPC) as an aid for practitioners to properly dose the antimicrobial they have selected. As stated earlier, the MIC is determined by evaluating susceptibility based on $10^5$ cfus/ml, but the MPC is performed using much higher concentrations of bacteria (up to $10^{10}$ cfus/ml) because it is thought that higher bacterial burdens can be present during acute infections and mutant cells may be present as well. Following incubation under ideal conditions, the lowest drug concentration blocking all growth is termed the mutant prevent concentration (MPC). While MPC testing may be a tool that helps prevent mutant pathogens and resistance, currently it is technically challenging and more expensive than standard MIC testing and not clinically available.

**Treatment and Management of Uncomplicated and Recurrent UTIs**

Appropriate antimicrobial therapy and periodic urine cultures are ideal when treating dogs and cats for bacterial UTIs. Empiric use of antimicrobial therapy should not be given unless absolutely necessary as the emergence of resistant bacteria is on the rise. For example, a recent publication from Canada reported an alarming antimicrobial resistance of members of the *Staphylococcus* genus isolated from canine UTI. However, if the animal has clinical signs and analgesics will not control these signs while waiting for a urine culture and susceptibility testing, empirical antimicrobial use is often prescribed. Appropriate doses should be administered and owners should be instructed on the importance of compliance.

Many animals will have a simple UTI, whereby the urine is sterilized during treatment and it remains sterile after the cessation of therapy. Although there are no studies in dogs and cats to determine duration of therapy for simple, uncomplicated UTIs, by convention, these are usually treated for 10-14 days.

If the dog or cat's urine is sterile during therapy, but the infection recurs weeks or months later, a reinfection or relapsing infection has occurred. Reinfections imply that a new organism or strain of bacteria has invaded the host, while a relapsing infection implies the same pathogen is present. Before pursuing with an extensive diagnostic work up, the clinician should question the client to be certain the correct medication was given and no doses were missed. If the medications were given as prescribed, and a reinfection or relapsing infection has been diagnosed, a search for predisposing causes for the infection should be pursued.

For recurrent (>3/year) or persistent infections, other diagnostics such as radiograph, contrast radiography, and/or ultrasound should be considered. Cystoscopy with mucosal biopsy should be considered to evaluate the patient for deep seated infections. It has been reported for dogs, that although urine cultures can be negative, the bladder mucosa or uroliths (if present) can yield positive growth. Furthermore, in mouse models, *E. coli* have been noted to develop within the superficial epithelial cells of the mouse bladder, forming intracellular bacterial communities. These pathogens can emerge once antibiotics have been discontinued.

Recurrent infections can also occur secondary to other predisposing factors such as metabolic diseases (e.g. Cushings, diabetes mellitus), therefore a CBC and biochemical profile should be evaluated in all dogs that have multiple or persistent infections. Other differentials for recurrent infections include a multitude of abnormalities that can occur within the urinary system. For example, a recessed vulva can predispose to UTIs; performing an episiotomy can prevent perivulvar pyoderma and improve anatomic defenses against uropathogens. Antibiotics should
be continued for at least 2-3 weeks after surgery before cessation. Micturition disorders such as urinary incontinence or urine retention should be addressed. If polypoid cystitis or urachal diverticuli are noted with imaging studies, removal of these structures can help remove the nidus for infections. In older dogs that present with recurrent UTIs, a search for urinary tract neoplasms should be performed. Finally, it is important that the antimicrobial chosen is appropriate for the pathogen being treated and that

Uroliths can predispose to UTIs by acting as a nidus for infection. The most common uroliths in cats and dogs are calcium oxalate and struvite. If an infection is found in an animal with a calcium oxalate stone, the presence of the stone in the bladder likely predisposed the dog to infection. However, struvite stones in dogs are usually formed by urease producing bacteria such as *Staphylococcus Pseudintermedius* and *Proteus* spp. Dissolution of these stones can be attempted with diet and antimicrobial therapy. Penicillins and the fluorquinolones can be good choices for these pathogens. The antibiotics must be given throughout the dissolution protocol.

The key to successfully managing complicated UTIs in dogs and cats is by evaluating urine culture throughout therapy. Ideally, the urine should be collected by cystocentesis and cultured 5-7 days after therapy has started and 5-7 days after cessation of the antimicrobial. This will allow the clinician to ascertain the difference between persistent and reinfections and guide further work up that may be necessary.

References:


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