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STANDARD ARTICLE

Risk factors for positive urine cultures in cats with subcutaneous ureteral bypass and ureteral stents (2010-2016)

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Background: Ureteral stent and subcutaneous ureteral bypass (SUB) placement are commonly used for managing ureteral obstructions. Urinary tract infection (UTI) is a recognized complication.

Objectives: To determine postoperative incidence of positive urine cultures in cats undergoing ureteral stent and SUB placement and to identify risk factors associated with positive urine cultures.

Design: Retrospective study.

Animals: Forty-three cats that underwent 48 surgical events.

Procedures: Medical records were reviewed. Cats were included if urine cultures were performed before and after surgery. Variables were compared to identify risk factors.

Results: Urine cultures were positive postoperatively pre-discharge in 5/20 (25%) cats. Median duration of follow-up post-discharge was 209 days (range, 11-2184 days), with a total of 143 urine cultures performed in cats post-discharge. Of these, 16 (11%) were positive in 12/48 (25%) cats. Nine different bacteria were identified; *Enterococcus* spp. (n = 8) predominated as monomicrobic or mixed infections. In 14/16 instances of positive urine cultures, affected cats had lower urinary tract signs, signs of pyelonephritis or both. Cats that received antibiotics postoperatively were significantly less likely to have a positive urine culture compared to those that did not (odds ratio, 0.2, 95% confidence interval, 0.05, 0.8, $P = 0.02$). Chronic kidney disease, renal implant type and postoperative urinary catheterization were not associated with positive urine cultures.

Conclusions and Clinical Relevance: Postoperatively, occurrence of positive urine cultures was similar to previous reports. Subclinical bacteriuria was less common than UTI. Postoperative urinary catheterization has been speculated to increase risk of bacteriuria, but this was not the case in this cohort.

KEYWORDS

feline, interventional radiology, renal decompression, ureter, urinary tract infection

1 | INTRODUCTION

Ureteral obstruction occurs commonly in cats and often is associated with substantial morbidity and mortality.[1] Underlying causes include ureterolithiasis (most commonly calcium oxalate),[1–4] ureteral strictures, and cellular debris such as dried solidified blood clots.[5,6] Medical management of ureteral obstruction generally is associated with poor long-term outcomes, and traditional surgical procedures have been associated with substantial morbidity and mortality in some studies.[1] As a result, newer approaches for renal decompression and preservation of renal function have been developed, including the placement of ureteral stents and subcutaneous ureteral bypass (SUB) systems. These interventional approaches provide effective management of ureteral

Abbreviations: cfu, colony-forming units; CKD, chronic kidney disease; hpf, high power field; ICU, intensive care unit; IRIS, International Renal Interest Society; JP, Jackson-Pratt; SUB, subcutaneous ureteral bypass; UC Davis VMTH, University of California, Davis William R. Pritchard Veterinary Medical Teaching Hospital; UTI, urinary tract infection.

obstruction in cats,[2–4] but they can be associated with complications, including development of urinary tract infection (UTI), re-obstruction, stent migration, and bladder irritation leading to dysuria.[2–4,7,8]

In human patients, a urinary conditioning film is deposited on ureteral stents, altering the surface characteristics of the stent and allowing for increased bacterial adhesion and biofilm formation.[9] This biofilm allows bacteria to persist even in the face of appropriate antibiotic administration. Bacterial colonization of ureteral stents in humans is presumed based on positive urine culture while the stent is indwelling and by stent culture after implant removal.[9] Bacterial colonization rates of ureteral stents in humans vary between 42% and 90%, but not all affected humans are symptomatic for UTI. In 1 study, only 38% of patients were symptomatic.[9,10] In humans, bacteriuria and bacterial stent colonization are significantly associated with the duration of time the ureteral stent is in place and the presence of systemic disease, such as chronic kidney disease (CKD) and diabetes mellitus.[9,10] Risk factors associated with UTI in cats with ureteral stents and SUB systems have not been described. In addition, although positive urine cultures have been reported in 12%-32% of cats after ureteral stent and SUB placement,[2,7,8] previous studies have not differentiated between subclinical bacteriuria and UTI. This differentiation is important in determining the clinical relevance of infections in this population of cats and determining which infections should be treated in cats with renal implants.

The objectives of our study were to identify risk factors associated with positive urine cultures in cats undergoing ureteral stent and SUB placement to relieve benign ureteral obstruction. We also aimed to report the incidence of subclinical bacteriuria and UTI in these cats. We hypothesized that UTI would occur more frequently than subclinical bacteriuria in this feline population. We also hypothesized that the use of urinary catheters would be a risk factor for developing positive urine culture during hospitalization and at follow-up.

2 | MATERIALS AND METHODS

Medical records of all cats examined at the University of California, Davis William R. Pritchard Veterinary Medical Teaching Hospital (UC Davis VMTH) for benign ureteral obstruction between 2010 and 2016 were reviewed for this retrospective study. Cats were included if they underwent placement of a unilateral or bilateral ureteral stent or SUB system or both. A single surgical event was defined as either unilateral or bilateral renal decompressive surgery performed under the same anesthesia. If a cat underwent a subsequent anesthetic event for renal decompression during another hospital admission, these renal decompressive surgeries were included as separate events. Only surgeries performed by or under the supervision of a single surgeon (W.T.N.C.) were included. To be included, cats were required to have a urine culture performed preoperatively and at least 1 urine culture performed after discharge. In addition, included cats must have survived to discharge from the hospital after surgical renal decompression. Data from follow-up visits at which urine cultures were performed were included for analysis. Cats were followed until death or they were lost to follow-up.

Urine cultures were categorized as positive if (1) the urine sample was collected by cystocentesis or from a SUB port and aerobic bacterial culture grew ≥10^3 colony-forming units (cfu)/mL or (2) the urine sample was collected by catheterization or voiding and aerobic culture grew ≥10^5 cfu/mL.[11] If the bacterial colony count was less than described above, the culture was considered positive only if clinical signs resolved with appropriate antimicrobial treatment, or if >1 consecutive culture was positive for the same organism. Urinary tract infection was defined by the presence of clinical signs (lower urinary tract signs, signs of pyelonephritis, or both) associated with positive urine culture.[11] Cats were diagnosed with lower urinary tract signs if they displayed ≥1 of the following clinical signs: dysuria, pollakiuria, stranguria, or hematuria. Pyelonephritis was diagnosed when positive urine culture was present in combination with a progressive increase in serum creatinine concentration from baseline, the presence of systemic clinical signs (ie, lethargy, hyporexia, vomiting, and fever), or both. For cats with clinical signs associated with positive urine culture, response to appropriate antibiotic treatment was considered to support the presence of UTI. Only new or recurrent positive urine cultures were included as true positive cultures. Recurrent positive urine cultures were defined as the presence of a positive culture and a previously negative culture, and included possible relapses, provided at least a single negative culture was documented in between positive cultures. If the same organism (persistent bacteriuria) was grown on serial urine cultures, only the first positive culture was included for analysis.[11]

Variables correlated with bacterial stent colonization in humans or variables speculated as potential risk factors for positive urine cultures in cats undergoing ureteral stent and SUB system placement were evaluated. The evaluated variables included preexisting CKD based on historical International Renal Interest Society (IRIS) staging before presentation for ureteral obstruction; presence of obstructive ureteral calculi based on abdominal ultrasound examination findings of a dilated ureter that tapered abruptly at the location of a suspected calculus; preoperative urine production (oligoanuria vs non-oligoanuria); serum creatinine and BUN concentrations at admission and before discharge from hospital; duration of anesthesia and surgery; unilateral vs bilateral surgery; placement of ureteral stent compared to SUB system; performing other intra-abdominal surgical procedures concurrently with renal decompression; placement of a urinary catheter, and if placed, duration of catheterization; placement of a Jackson-Pratt (JP) drain, and if placed, duration of placement; time of hospitalization in the intensive care unit (ICU); use of antibiotics preoperatively and postoperatively; and, occurrence of diarrhea at any time point during hospitalization. Duration of urinary catheterization and indwelling time of JP drain were given values of 0 if they were removed immediately postoperatively before anesthetic recovery. The cause of ureteral obstruction was not reported as it was not consistently recorded in the medical records and could not be determined retrospectively in many cases.

Standard urinary catheter care at UC Davis VMTH comprises cleaning of the external urinary catheter with dilute chlorhexidine every 8 hours while indwelling. In addition, all urinary collection systems are closed and placed on a barrier; therefore, they are not in direct contact with the hospital floor.

Continuous variables were assessed for normality using the Shapiro-Wilk test. Because most variables were not normally distributed, the median (minimum-maximum) value was used to describe these variables for consistency. An unpaired *t* test was used to compare parametric continuous variables between groups, and a Mann-Whitney test was used for nonparametric continuous variables. The Spearman rank correlation test or Pearson's correlation was used to assess the relationship between continuous variables depending upon whether they were not normally or normally distributed, respectively. Categorical variables were described using proportions (%) and odds ratios (OR) with 95% confidence intervals (CI) and determined using Woolf's method. For all comparisons, a *P*-value <.05 was considered significant. All statistical analyses were performed using a statistical software package (Stata 14.0 for MAC; Stata Corporation, College Station, Texas).

3 | RESULTS

Forty-three cats that underwent 48 renal decompressive surgical events (both unilateral and bilateral) met the inclusion criteria. An additional 22 cats were identified as having undergone renal decompressive surgeries but were excluded because no urine culture was performed before surgery (n = 3), the cat died before discharge (n = 8), or no follow-up urine cultures were available (n = 11).

Median age at the time of surgery was 108 months (range, 5-192 months). Of the 43 cats, 25 (58%) were castrated males and 17 (44%) were spayed females. Thirty-two of 43 (74%) were domestic shorthair cats; other breeds were domestic medium hair (n = 4), domestic longhair (n = 2), Siamese (n = 2), Ocicat (n = 1), Sphinx (n = 1), and American shorthair (n = 1). Of the 43 cats included in the study, 22 (51%) had previously been diagnosed with either IRIS stage 2 or 3 CKD a median of 5 months before surgery (range, 1-48 months).

Twenty-four of the 48 (50%) cats had obstructive ureteral calculi visualized on abdominal ultrasound examination. Before surgery, 9 of the 48 (19%) cats were oligoanuric; all others were reported to have normal or increased urine output.

Of the 48 surgical events, 30 (63%) were unilateral surgeries and 18 (37%) were bilateral surgeries. Four of 43 cats (9%) underwent multiple separate surgical events during different hospitalizations for treatment of ureteral obstruction in either the ipsilateral or contralateral kidney. One of these cats underwent 3 separate renal decompressive surgical events during separate hospitalizations (each was included in the analysis): placement of a left ureteral stent for left ureteral obstruction, placement of a right ureteral stent for right ureteral obstruction, and placement of a right SUB system to treat recurrent right ureteral obstruction while the ureteral stent was indwelling. In 1 cat that underwent 2 separate surgical events, the first surgical event (placement of a unilateral ureteral stent) was excluded because a preoperative urine culture was not performed. As a result, only its 2nd surgery (placement of bilateral SUB systems to treat bilateral ureteral obstruction while the unilateral ureteral stent was indwelling) was included in the analysis. The remaining 2 cats underwent initial unilateral ureteral stent placement, and because of the recurrent ureteral obstruction on the ipsilateral side, they underwent SUB system placement. The breakdown of renal decompressive surgeries performed in the cats is provided in Table 1.

TABLE 1 Type of renal decompressive surgeries performed (n = 48)

Procedure	Number
Unilateral ureteral stent	20 (42%)
Bilateral SUB	11 (23%)
Unilateral SUB	10 (21%)
Bilateral ureteral stents	5 (10%)
Ureteral stent and SUB	2 (4%)

Abbreviations: SUB, subcutaneous ureteral bypass.

The median duration of anesthesia and surgery was 5.5 hours (range, 3-9 hours) and 3 hours (range, 1.5-6 hours), respectively. A concurrent intra-abdominal surgical procedure was performed during 9 of the 48 (19%) cats undergoing surgical events and included full-thickness gastrointestinal biopsy (n = 4), cystic calculi removal (n = 3), and liver lobectomy or biopsy (n = 2). During most surgical events (45/48; 92%), an esophageal feeding tube was placed. Of the 48 cats, in 39 (81%) instances, a urinary catheter was placed immediately after surgery, with a median duration of catheterization of 45 hours (range, 0-164 hours). A JP drain was placed in 20 of the 48 (42%) cats for the management of possible uroabdomen secondary to ureterotomy for stone removal or ureteral trauma during wire and stent placement, including 10 of 29 (34%) ureteral stent placements and 6 of 19 (32%) SUB placements. The median duration of time devices were in place after surgery was 73 hours (range, 0-211 hours). Cats spent a median of 63 hours in the ICU after surgery (range, 0-218 hours). The median total duration of hospitalization was 10 days (range, 4-18 days), with a median duration of hospitalization after surgery of 7 days (range, 3-16 days).

With the initial urine culture results pending, antibiotics were administered preoperatively in 20 of the 48 (42%) cats and postoperatively in 33 of the 48 (69%) cats. The median duration of preoperative antibiotic use was 2 days (range, 1-5 days) and postoperative antibiotic use was 5 days (range, 2-11 days). The duration of antibiotic use could not be determined in 2 cats from the available medical records. The most commonly prescribed antibiotics postoperatively were enrofloxacin (n = 19), ampicillin sulbactam (n = 16), and ampicillin (n = 6). Antibiotics were administered intraoperatively during 44 of the 48 (92%) cats. One cat did not receive antibiotics intraoperatively, and no documentation of antibiotic administration was available in 3 of the 48 (6%) surgical events.

In 40 of the 48 (83%) cats, azotemia was identified before surgery, with 41 of the 48 (85%) cats having increased serum creatinine concentrations and 40 of the 48 (83%) cats having increased BUN concentrations. The median serum creatinine and BUN concentrations at presentation were 6.5 mg/dL (range, 1.1-20.3 mg/dL; reference range, 1.1-2.2 mg/dL) and 80 mg/dL (range, 16-314 mg/dL; reference range, 18-33 mg/dL), respectively. Before discharge, median serum creatinine concentration was 2.2 mg/dL (range, 0.6-4.8 mg/dL) and median BUN concentration was 28 mg/dL (range, 7-85 mg/dL). Azotemia resolved before discharge from the hospital in 24 of the 48 (50%) cats undergoing surgical events.

Urine culture was performed in all cats before surgery, with 1 of 48 (2%) cultures being positive. In this cat, urine was collected by urethral catheterization. Urine sediment examination disclosed pyuria (6-8 white blood cells per high-power field [hpf]) and hematuria (25-50 red blood cells per hpf), and aerobic culture grew 10^5 cfu/mL *Escherichia coli*. A sample from the renal pelvis at surgery 24 hours after starting antibiotics was negative. Twenty of the 48 (42%) cats had urine cultures performed before discharge from the hospital, and 5 of 20 (25%) urine cultures were positive (*E. coli* [n = 2], *Enterococcus faecium* [n = 1], *Mycoplasma* spp. [n = 1], and *Pseudomonas aeruginosa* [n = 1]). Three of 5 cats with positive urine cultures had received antibiotics postoperatively. Of these 5 cats with positive urine cultures before discharge, 3 of 5 had undergone bilateral SUB system placement, 1 of 5 had undergone unilateral stent placement, and 1 of 5 had a ureteral stent and SUB system placed during a single anesthetic episode for the treatment of bilateral ureteral obstruction. In no instance, was there a positive culture postoperatively where there had been a positive urine culture before surgery.

The median duration of follow-up was 209 days (range, 11-2184 days), with first post-discharge urine culture performed at a median of 15 days. After discharge, 143 urine cultures were performed, with 130 (91%) collected by ultrasound-guided cystocentesis. The remaining urine samples were collected using the SUB system port (n = 6), urethral catheterization (n = 1), voiding (n = 1), and bladder wall biopsy (n = 1). The method by which urine was collected was not recorded in 4 instances. Of 143 post-discharge urine cultures, 16 (11%) were positive in 12 of the 48 (25%) cats undergoing separate surgical events. These positive urine cultures were collected by cystocentesis (n = 9), from the SUB system port (n = 1), as a bladder wall biopsy at a separate surgery (with no concurrent renal decompressive surgery) for cystic calculi removal (n = 1), and voiding (n = 1). A voided urine sample had to be collected because marked pollakiuria prevented collection by cystocentesis. Given the cat's clinical signs and resolution of these signs with antibiotic treatment, this culture result was suspected to represent UTI rather than contamination. Two of the 48 (4%) cats had >1 positive urine culture documented. The median time from discharge to identification of the 1st positive urine culture was 55 days (range, 4-109 days). Seven bacteria were identified, with *Enterococcus* spp. predominating (Table 2). Three cats with positive urine cultures during hospitalization had at least 1 positive urine culture at follow-up after discharge including 1 cat with recurrent UTI.

Of the 12 cats with positive urine cultures at follow-up after discharge, 6 represented unilateral or bilateral ureteral stent placement, 5 represented unilateral or bilateral SUB system placement, and 1 represented both ureteral stent and SUB system placement. No statistically significant difference in the rates of positive urine cultures were found between cats with stents and SUB systems or between cats with unilateral and bilateral implants.

Clinical signs consistent with UTI were present in 14 of 16 (93%) surgical events at the time of positive urine culture. The anatomical location of UTI based on clinical signs was lower urinary tract (n = 6), upper urinary tract (n = 5), or a combination of these (n = 3). Resolution or improvement of clinical signs occurred with appropriate antibiotic treatment in 9 of 14 cats. Follow-up negative urine culture was associated with resolution of clinical signs in 8 of 9 cats, supporting the presence of bacterial cystitis rather than implant-related cystitis. One cat did not have a follow-up urine culture performed; however, its clinical signs resolved with appropriate antibiotic treatment. Response to treatment could not be determined in the remaining 5 cats because of persistent infection (n = 3) or death (n = 2). Of 6 cats infected with *Enterococcus* spp. alone, 5 (83%) displayed clinical signs, including suspected pyelonephritis in 2 instances.

Cats that received antibiotics postoperatively before discharge were significantly less likely to develop positive urine culture at follow-up compared to those that did not (OR, 0.2; 95% CI, 0.05-0.8; $P = .01$). The remaining variables evaluated were not significantly associated with a change in risk of developing positive urine cultures during hospitalization or at follow-up after discharge from the hospital.

TABLE 2 Bacteria present in positive urine cultures post-discharge

Bacteria	Number
Enterococcus spp.	6/16 (38%)
Escherichia coli	3/16 (19%)
Staphylococcus pseudintermedius	2/16 (13%)
Coagulase-negative *Staphylococcus*	1/16 (6%)
Klebsiella oxytoca	1/16 (6%)
Pseudomonas aeruginosa and *Enterococcus* spp.	1/16 (6%)
E. coli and *Enterococcus* spp.	1/16 (6%)
E. coli and *Citrobacter freundii*	1/16 (6%)

4 | DISCUSSION

Clinically relevant UTI were documented commonly in this cohort of cats that underwent renal decompression using ureteral stents, SUB systems or both, with positive urine cultures present at follow-up in 25% of instances, of which 93% were classified as being consistent with UTI. Cats that did not receive antibiotics postoperatively had significantly increased risk for the development of positive urine culture after discharge from the hospital.

The incidence of UTI in cats with benign ureteral obstructions is reported to vary from 0% to 33%,[2,4,7] but these studies did not differentiate between subclinical bacteriuria and UTI. In our study, positive urine cultures in cats with benign ureteral obstruction managed surgically were rare preoperatively, with only a single cat having a positive urine culture. However, 25% of urine cultures performed before discharge were positive. Urine cultures were performed postoperatively and before discharge in <50% of cats. Thus, although it appears that positive urine cultures might occur frequently in the hospital after renal decompressive surgery, selection bias is possible because cats with clinical signs compatible with UTI may have been more likely to have urine culture performed as urine cultures were performed at the discretion of the attending clinician. No risk factors, including urinary catheter placement, were identified for positive urine cultures before discharge from the hospital.

Positive urine cultures were common at follow-up after discharge from the hospital, with 25% of cats having at least 1 positive urine culture. This finding differs from a previous study, which reported that although 32% of cats developed UTI within the first month after ureteral stenting, only 13% of cats developed UTI beyond 1 month of ureteral stent placement.[2] Other studies have shown similar infection rates to those in our study, with an infection rate in cats with ureteral stents and SUB systems of approximately 31%[8] and recurrent or persistent UTI identified in 26% of cats with ureteral stents.[7] Ours is the 1st study to distinguish between subclinical bacteriuria and UTI. In our study, 14 of 16 (93%) cats undergoing separate renal decompression surgeries had a UTI, whereas 2 of 16 (7%) had subclinical bacteriuria. Although it can be difficult to definitively distinguish between subclinical bacteriuria and UTI, we used stringent inclusion criteria for a cat to be diagnosed with UTI, including the presence of clinical signs with a positive urine culture in addition to resolution of clinical signs with appropriate antibiotic treatment and a follow-up negative urine culture that correlated with resolution of clinical signs in most cases. Our findings suggest that many positive urine cultures are clinically relevant. The ability to document improvement or resolution of clinical signs with appropriate treatment is important given that similar clinical signs can occur with sterile implant-induced inflammation and irritation as well as urolithiasis.[2] Furthermore, it is unclear whether the lack of clinical signs in a patient with a positive urine culture and renal implant precludes the need for treatment, particularly because of the risk of biofilm formation. Further studies are needed to evaluate this possible need.

Enterococcus spp. were isolated most frequently in our study, both as a monomicrobic infection and in mixed infections with other organisms. In many cases, *Enterococcus* spp. has been reported to be less pathogenic and thus associated with subclinical bacteriuria rather than UTI.[12] In our study, most cats with urine cultures positive for *Enterococcus* spp. (even monomicrobic infections) had clinical signs of UTI and therefore were treated. The importance of *Enterococcus* spp. in cats with urinary implants lies in both its inherent and acquired mechanisms of antimicrobial resistance[13] as well as its ability to form biofilms on implants,[14,15] rendering it more resistant to killing by antimicrobials.[16] It is also a common hospital-acquired infection.[13]

The postoperative use of antibiotics significantly decreased the risk of development of positive urine cultures in this cohort of cats at follow-up after discharge, with antibiotics being used for a median of 5 days postoperatively. These results come from a small number of cats and should be interpreted with caution to avoid overuse of antibiotics. There are, however, several speculative reasons why postoperative antibiotic use may have resulted in decreased numbers of positive urine cultures. First, the use of antibiotics postoperatively may be associated with decreased bacterial colonization of the renal implant immediately after surgery. This effect may be important, especially because *Enterococcus* spp. infections are commonly associated with biofilms and implants, and were the most commonly cultured bacteria in the population studied. The use of antibiotics postoperatively may also facilitate healing of damaged urothelium, thereby allowing restoration of healthy urothelium that may be less likely to support bacterial colonization postoperatively. Additional studies, particularly prospective clinical trials, are warranted to assess this finding further so as to minimize unnecessary antibiotic use.

Urinary catheterization postoperatively was not identified as a risk factor for development of positive urine culture in cats in our study although 81% of cats had urinary catheters in place postoperatively. Urinary catheterization previously has been reported as a risk factor for development of UTI in cats,[17,18] likely associated with introduction of bacteria into the urinary bladder and damage to the bladder and urethral mucosa. Our results suggest that urinary catheterization can be used to facilitate management of these patients in the postoperative period without altering the risk of UTI. Nonetheless, higher case numbers should be evaluated, especially given that most cats included in our study had urinary catheters in place during the postoperative period.

Fifty-one percent of cats had IRIS stage 2-3 CKD diagnosed before renal decompressive surgery. Urinary tract infections have been reported in 17%-29% of cats with CKD, but the number of cats with clinical signs varies from 1% to 5% in these reports.[19–21] It is impossible to definitively determine whether infections in these cats were related to the presence of an implant or the presence of underlying CKD, but the fact that only 1 of 48 cats had an infection preoperatively suggests that infections were not likely related to CKD present before surgery. In addition, for the cats in our study, the presence of clinically relevant CKD (IRIS stage 2-3) was not identified as a risk factor for development of a positive urine culture. Furthermore, a higher percentage of cats in this report had clinical signs consistent with UTI, as compared to what has been reported previously in cats with CKD and no implant.[19–21] This observation again supports that UTI in this cohort of cats with ureteral implants occurred independently of concurrent CKD. A limitation of the definition of CKD used in our study is that cats with ultrasonographic changes consistent with CKD but without previous diagnosis of CKD based on laboratory test results were not categorized as having CKD during analysis.

One consideration that should be made is whether urine cultures were more likely to be performed in cats with clinical signs of UTI post-discharge. In our hospital, because of potential increased risk for positive urine cultures in cats with compromised renal function, renal implants, or both, urine cultures typically are performed during routine follow-up evaluations. Given this consideration and the high number of negative urine cultures, it is unlikely that selection bias played an important role in the number of positive urine cultures.

Some of the limitations of our study are reflected in its retrospective nature and small study population. Furthermore, the follow-up available for patients was highly variable. Some cats included in the study may have had UTI identified and treated by their primary veterinarians, falsely decreasing the frequency of positive urine cultures detected. However, most cats with renal implants are followed up at our hospital for at least the first several months after renal decompression. In addition, urine cultures were not performed at all visits, which makes it impossible to determine the true incidence of subclinical bacteriuria, but this should not affect the number of clinically relevant UTI.

After renal decompressive surgery, positive urine cultures occurred commonly in the cats included in our study. *Enterococcus* spp. was an important pathogen, but other bacteria also were identified. Further investigation of postoperative antibiotic use might help better characterize the incidence and importance of UTI in cats after renal decompressive surgery and might allow for improved management. In addition, future studies should allow for a better understanding of subclinical bacteriuria and UTI in cats with upper urinary tract implants.

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CONFLICT OF INTEREST DECLARATION

Two authors (Carrie A. Palm and William T. N. Culp) teach laboratories that utilize equipment included in this study.

OFF-LABEL ANTIMICROBIAL DECLARATION

Enrofloxacin was administered IV to cats in this study.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Authors declare no IACUC or other approval was needed.

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

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