Incidence of catheter-associated urinary tract infection among dogs in a small animal intensive care unit

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Objective—To determine incidence of and possible risk factors for catheter-associated urinary tract infection (UTI) among dogs hospitalized in an intensive care unit and compare results of bacterial culture of urine samples with results of bacterial culture of catheter tips.

Design—Prospective study.

Animals—39 dogs.

Procedure—A standard protocol for aseptic catheter placement and maintenance was used. Urine samples were obtained daily and submitted for bacterial culture. When possible, the urinary catheter tip was collected aseptically at the time of catheter removal and submitted for bacterial culture. Bacteria that were obtained were identified and tested for antimicrobial susceptibility.

Results—4 of the 39 (10.3%) dogs developed a UTI. The probability of remaining free from UTI after 1 day in the intensive care unit was 94.9%, and the probability of remaining free from UTI after 4 days was 63.3%. Bacteria isolates were generally common urinary tract pathogens and were susceptible to most antimicrobials. Specific risk factors for catheter-associated UTI, beyond a lack of antimicrobial administration, were not identified. Positive predictive value of bacterial culture of urinary catheter tips was only 25%.

Conclusions and Clinical Relevance—Results suggest that placement of an indwelling urinary catheter in dogs is associated with a low risk of catheter-associated UTI during the first 3 days after catheter placement, provided that adequate precautions are taken for aseptic catheter placement and maintenance. Results of bacterial culture of urinary catheter tips should not be used to predict whether dogs developed catheter-associated UTI. (*J Am Vet Med Assoc* 2004;224:1936–1940)

Catheter-associated **urinary tract infections (UTIs)** are thought to occur as a result of the introduction of bacteria into the bladder during placement of an indwelling catheter or the migration of bacteria along the surface of the catheter after it has been placed.[1-6] In a previous study,[7] 20% of female dogs for which results of bacterial culture of a urine sample had previously been negative developed bacteriuria after a single catheterization of the urinary bladder, with the same bacteria recovered from the urine as were recovered from the urethral orifice. In contrast, male dogs did not develop bacteriuria after a single catheterization.

Catheter-associated UTIs may lead to ascending infection, bacteremia, or sepsis.[5] Thus, limiting placement of indwelling urinary catheters to appropriate patients has been recommended.[8] In people, for instance, it has been recommended that urinary catheters be placed only to relieve urinary tract obstruction, permit urinary drainage in patients with neurogenic bladder dysfunction and urine retention, aid in urologic surgery or surgery on contiguous structures, or obtain accurate measurements of urinary output in critically ill patients.[8] In critically ill dogs, indwelling urinary catheters allow for quantification of urine output, which is important in adjusting fluid therapy to provide for adequate tissue perfusion while avoiding volume overload, recognizing oliguria, and assessing other measures of renal function such as glomerular filtration rate.[9] However, concerns for increases in morbidity and mortality rates secondary to catheter-associated UTI persist, and nosocomial outbreaks of catheter-associated UTI in veterinary **intensive care units (ICUs)** have been reported.[1,3]

In a previous study,[2] 11 of 20 (55%) hospitalized dogs for which results of bacterial culture of initial urine samples were negative developed catheter-associated UTIs, and in a separate study,[3] 8 of 21 (38%) dogs in a **small animal ICU (SAICU)** developed catheter-associated UTIs. Both these studies suggested that duration of catheterization was a risk factor for the development of UTI and that antimicrobial administration was associated with development of antimicrobial-resistant bacterial infections in dogs that underwent prolonged catheterization. However, neither identified a predilection for development of UTI among female dogs.

While these studies contributed valuable information to the veterinary literature, there is a need for further research. In particular, differences in hospitalized patient populations and protocols for placement and care of indwelling urinary catheters, along with changes in bacteria isolated from hospitalized dogs and antimicrobial-resistance patterns of bacteria that are recovered, indicate that further investigation is war-

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ranted. Also, our subjective assessment of the incidence of catheter-associated UTIs among dogs at the University of California SAICU did not concur with incidences reported in these previous studies. Thus, the purposes of the study reported here were to determine the incidence of catheter-associated UTI among dogs hospitalized in a university-level SAICU and to identify causative bacteria, their antimicrobial resistance patterns, and possible risk factors for development of catheter-associated UTI. Because results of bacterial culture of urinary catheters and urine samples do not necessarily correlate in people,[10] we also wanted to determine whether results of bacterial culture of urine samples matched results of bacterial culture of catheter tips in dogs with catheter-associated UTI.

Materials and Methods

Dogs—Dogs hospitalized in the University of California, Davis, SAICU between February 2001 and May 2003 that had a bacterial culture of a urine sample obtained by cystocentesis during the 12 hours prior to catheter placement were eligible for enrollment in the study. Dogs that had undergone urinary catheterization during the week prior to admission to the SAICU or that were known to have a UTI at the time of admission were excluded from the study, as were dogs in which an indwelling urinary catheter was not in place for at least 24 hours, dogs in which results of the bacterial culture were positive, and dogs that were discharged from the SAICU before the urinary catheter had been in place for 24 hours.

The study was designed as a prospective study. Information obtained for each dog enrolled in the study included signalment, indication for urinary catheter placement, urinary catheter type, time required to place the urinary catheter, active problem list, antimicrobials administered during the 24 hours prior to catheter placement, time a urinary catheter was in place, whether there were any breaks in the closed urine collection system, and antimicrobials administered while a urinary catheter was in place. In dogs that developed a UTI after urinary catheter placement, treatment, response to treatment, and whether sepsis was identified (ie, on the basis of results of bacterial culture of blood samples or clinical impressions of the attending clinician) were documented. Whether dogs died while in the SAICU or were discharged alive was recorded for all dogs.

Urinary catheter placement, care, and monitoring—Small animal ICU personnel placed all urinary catheters; a standard protocol was followed in all instances. Briefly, hair was clipped from the vulvar area or preputial opening to a distance of at least 5 cm from the catheter insertion site. The area was prepared with chlorhexidine scrub[a] and tap water. Aseptic technique was maintained by the use of sterile barrier drapes, surgical gloves, and sterile lidocaine jelly. In females, the vaginal vault was flushed with 2 to 10 mL of 0.05% chlorhexidine solution[b] 5 times. A silicone-coated latex Foley catheter[c] of appropriate size was then advanced into the bladder after digital palpation of the urethral papilla. If catheterization was initially unsuccessful, a polypropylene catheter, disinfected laryngoscope speculum, vaginal speculum, or otoscope cone was used to assist in the placement of the Foley catheter. In males, the penis was extruded and cleaned of any gross exudate. The prepuce was then flushed with 2 to 10 mL of 0.05% chlorhexidine solution 5 times. With the penis still extruded, a silicone-coated Foley catheter[d] of appropriate size was advanced into the bladder. In both males and females, once the catheter tip was in the bladder, the balloon was inflated with sterile saline (0.9% NaCl) solution and the catheter was retracted until resistance was met. A sterile closed collection system was immediately connected to the catheter following placement. Every 8 hours, or whenever the urinary catheter became visibly soiled, the exposed portion of the catheter was wiped with 0.05% chlorhexidine solution and the vulvar or preputial area was cleaned and flushed with 0.05% chlorhexidine solution. Reflux of urine into the bladder was prevented by ensuring proper operation of the urine collection bag check valve and by keeping the urine collection bag at a level below the level of the bladder. In the event urine flow was in question, patency of the catheter was confirmed by retrograde injection of sterile saline solution via an infusion plug.

A urine sample was collected through the infusion plug with a 25-gauge needle and syringe every 24 hours following catheter placement and was submitted for bacterial culture. When possible, the urinary catheter tip was collected aseptically at the time of catheter removal and submitted for bacterial culture.

Bacterial culture techniques—Urine samples and catheter tips were refrigerated at approximately 4°C until processed; all were processed within 12 hours of collection. Specific gravity of urine samples was measured with a refractometer, and a dipstick[e] was used to test for glucosuria. Urine samples were plated on MacConkey and sheep blood agar plates[f]; catheter tips were plated by rolling them on MacConkey and sheep blood agar plates. Plates were incubated at 37°C and examined for bacterial and fungal growth every 24 hours for 5 days.

Colony counts were performed on all urine samples from which growth was obtained. Dogs were considered to have a UTI infection if the bacterial colony count for a urine sample was $\geq 10^3$ organisms/mL. Microorganisms were identified and antimicrobial susceptibility profiles were determined by the University of California, Davis, Microbiological Diagnostic Laboratory. A commercially available assay[g] incorporating a microbroth dilution technique was used to determine antimicrobial susceptibility. All procedures were performed in accordance with the manufacturer's directions and NCCLS standards. Organisms were tested for susceptibility to ampicillin, amoxicillin-clavulanic acid, cephalexin, trimethoprim-sulfamethoxazole, and enrofloxacin.

Data analysis—Data were entered in a computerized spreadsheet.[h] A dog was considered to be free from UTI up to the day of collection of the first urine sample for which results of bacterial culture were positive. The Kaplan-Meier product-limit method was used to evaluate the probability of remaining free from UTI as a function of time. The exact χ^2 test was used to test for an association between individual breeds versus all breeds and development of UTI. The log-rank test was used to test whether antimicrobial administration, sex, or neutering status was associated with the rate of UTI. Values of $P < 0.05$ were considered significant. Sensitivity, specificity, positive predictive value, and negative predictive value of using results of bacterial culture of urinary catheter tips to predict whether dogs had developed a UTI were calculated by use of standard equations.

Results

Thirty-nine dogs completed the study, of which 23 were male (7 sexually intact and 16 neutered) and 16 were female (4 sexually intact and 12 spayed). Age ranged from 8 months to 13 years (mean ± SD, 6.3 ± 3.7 years). There were 29 purebred dogs representing 23 breeds, including 3 Golden Retrievers, 3 German Shepherd Dogs, 2 Labrador Retrievers, and 2 Border Collies, and 10 mixed-breed dogs, including 3 German

Shepherd Dog crosses and 2 Labrador Retriever crosses. Mean ± SD duration of urinary catheterization was 2.2 ± 1.8 days (mode, 2 days; range, 1 to 8 days). Urinary catheters were placed to allow for measurement of urinary output in 35 dogs, because of detrusor dysfunction in 1 dog, and to assist in patient management in 3 dogs that were recumbent.

Four of the 39 (10.3%) dogs developed a UTI. For 2 dogs, bacteria were recovered from urine samples collected 24 hours after catheter placement. For the other 2, bacteria were recovered from urine samples collected 4 days after catheter placement. The 2 dogs from which bacteria were recovered 24 hours after catheter placement consisted of a 1-year-old spayed female German Shepherd Dog cross being treated for hydroxyzine toxicosis[11] and a 9-year-old neutered male Labrador Retriever cross that had received caudal-half-body radiation for lymphosarcoma. The 2 dogs that developed UTI on day 4 consisted of a 4-year-old sexually intact male German Shepherd Dog that had traumatic brain injury and a sexually intact female German Shepherd Dog that was recumbent because of multiple fractures. In the latter dog, the urinary catheter had been placed to assist in patient management; in the other 3, urinary catheters had been placed to monitor urinary output.

Proteus mirabilis and *Klebsiella pneumoniae* were isolated from the urine of the dog being treated for hydroxyzine toxicosis; these isolates were susceptible to all of the antimicrobials tested. Hemolytic *Escherichia coli* and *Streptococcus canis* were isolated from the urine of the dog that had undergone caudal-half-body radiation; isolates were susceptible to all of the antimicrobials tested. *Acinetobacter calcoaceticus* was isolated from the urine of the dog with the traumatic brain injury; the organism was susceptible to all antimicrobials tested except for cephalexin. *Pseudomonas aeruginosa* was isolated from the urine of the dog with fractures; the organism was resistant to ampicillin, amoxicillin-clavulanic acid, and cephalexin but susceptible to enrofloxacin and trimethoprim-sulfamethoxazole. In all 4 dogs, UTI resolved with antimicrobial treatment, as determined by means of bacterial culture of a urine sample obtained by means of cystocentesis following treatment.

Urinary catheters were in place in dogs in the study a total of 85 dog-days. Thus, the rate of UTI was 0.047 infections/dog-day of catheterization or approximately 5 incident UTIs/100 dog-days of catheterization. Overall, the probability of remaining free from UTI after 1 day in the SAICU was 94.9% (95% **confidence interval [CI]**, 81% to 98.7%), and the probability of remaining free from UTI after 4 days in the SAICU was 63.3% (95% CI, 20.4% to 87.7%; **Fig 1**). Neither sex ($P = 0.84$) nor neutering status ($P = 0.85$) was significantly associated with rate of UTI. German Shepherd Dogs (purebred and crossbred) were significantly ($P = 0.008$) more likely to develop UTI than were dogs of other breeds.

Urinary catheter tips from 19 dogs were submitted for bacterial culture. Results were positive for 8 (2 from dogs with UTI and 6 from dogs without) and negative for 11 (all from dogs without UTI). Sensitivity of using results of bacterial culture of urinary catheter tips to predict whether dogs had developed a UTI was 100% (95% CI, 22% to 100%), specificity was 65% (95% CI, 38% to 86%), positive predictive value was 25% (95% CI, 3% to 65%), and negative predictive value was 100% (95% CI, 76% to 100%).

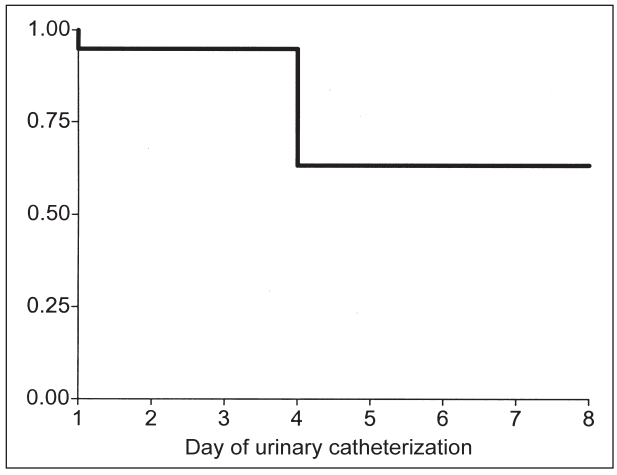

Figure 1—Kaplan-Meier plot of the probability of remaining free from catheter-associated urinary tract infection as a function of duration of catheterization for 39 dogs hospitalized in a small animal intensive care unit.

Thirty-one dogs were given antimicrobials from 24 hours prior to catheter placement to the time of catheter removal or discharge from the SAICU. Antimicrobials that were administered included ticarcillin-clavulanic acid (n = 12), enrofloxacin (10), cefazolin (10), ampicillin (8), amoxicillin-clavulanic acid (3), cefotetan (2), doxycycline (1), amikacin (1), cephalexin (1), and metronidazole (1). Dogs administered antimicrobials during this period were significantly ($P = 0.007$) less likely to develop UTI than were dogs that did not receive antimicrobials.

Discussion

The 10.3% incidence of catheter-associated UTI in the present study was less than incidences reported in 2 previous studies[2,5]; however, there were important differences among these studies. Mean durations of catheterization in the previous studies were 5 and 12 days, compared with 2 days in the present study, and duration of catheterization has been reported to be a risk factor for development of a catheter-associated UTI.[2] The shorter duration of catheterization in the present study may reflect differences in indications for placement of an indwelling urinary catheter and patient populations. For most dogs in the present study, a urinary catheter was placed so that urinary output could be measured; whereas in 1 of the previous studies,[2] catheters were placed because of urinary tract obstruction or trauma (5/20), to determine urinary output (3/20), because of detrusor dysfunction (3/20), to assist with care of dogs that had undergone prostatectomy (3/20), and to assist with management of recumbent dogs (6/20). In the other study,[5] 4 of the 8 dogs that developed a catheter-associated UTI were paraparetic or tetraparetic because of spinal cord disease, 3 had apparently had a urinary catheter placed for

determination of urinary output, and 1 had had a catheter placed because of urethral trauma. The shorter duration of urinary catheterization in this study may also reflect the population of critically ill dogs admitted to the University of California SAICU.

Another factor that may help explain the difference in incidence of catheter-associated UTI between the present and previous studies[2,5] may have been the protocol for catheter placement and maintenance that was used. Urinary catheters that were used differed in composition, and because biofilm formation and bacterial swarming are dependent on the catheter material,[12-16] this may have played a role in the higher incidence of catheter-associated UTI in the previous studies. No vaginal or preputial flushing or ongoing catheter care was reported in the previous 2 studies, and this may also have contributed to the lower incidence in the present study. However, meatal care in humans, including use of disinfectants, has not been shown to be of any benefit.[6,17]

In the present study, dogs were considered to have a catheter-associated UTI if the colony count for a urine sample was $\geq 10^3$ organisms/mL. In contrast, in 2 previous studies,[2,5] colony counts of $\geq 10^4$ organisms/mL of urine from male dogs and $\geq 10^5$ organisms/mL of urine from female dogs were used as the definition of UTI. Thus, a stricter definition was used in the present study. Additionally, urine samples were collected daily starting 24 hours after catheter placement in the present study, whereas initial urine samples were collected 48 hours after catheter placement in a previous study[5] and only on weekdays in the other.[2] These differences may have increased the likelihood that a UTI would have been detected in the present study.

In this study, as in previous studies,[2,5] sex of the dog was not associated with risk of catheter-associated UTI. In contrast, sex was associated with risk of UTI following onetime catheterization in dogs[7] and people.[18] German Shepherd Dogs were not reported to have a predisposition for development of UTI in a recent study[19]; however, their overrepresentation in the present study raises concerns that they could have such a predisposition. A larger study is warranted before any conclusions can be drawn from this observation.

Bacteria isolated from dogs in the present study were common urinary tract pathogens, with the exception of *A calcoaceticus*.[1,3,19] Unlike findings in previous studies,[2,5] bacterial isolates in the present study had minimal resistance to antimicrobials. This may have been related to the short duration of catheterization. All dogs in the present study that developed a catheter-associated UTI had their catheters removed within 24 hours after positive bacterial culture results were obtained, whereas dogs in previous studies continued to have an indwelling catheter after a diagnosis of catheter-associated UTI was made. Three of the 4 dogs in this study that developed a UTI had not been given antimicrobials while the urinary catheter was in place. Antimicrobial administration is a risk factor in people[6,18] and dogs[2,5] for the development of resistant infections.

Although dogs treated with antimicrobials prophylactically were significantly less likely to develop UTI than were dogs that did not receive antimicrobials in the present study, routine prophylactic use of antimicrobials cannot be recommended. A longer duration of catheterization has been associated with a higher risk of UTI with antimicrobial-resistant bacteria,[2,5,6,18] and because one cannot predict how long a urinary catheter will be needed at the time of initial placement, prophylactic antimicrobial administration should be used only under special circumstances. For instance, prophylactic antimicrobial administration might be justified in dogs in which catheterization is expected to be short term and there is a high risk of bacteriuria. Our findings support the notion that infections that develop in patients not receiving antimicrobials are generally not caused by resistant organisms.

Bacterial culture of urinary catheter tips to diagnose catheter-associated UTI has been shown to be unreliable in people.[10] The high sensitivity and negative predictive value for bacterial culture of urinary catheter tips in the present study suggest that this technique could provide initial screening information. However, the low specificity and positive predictive value suggest that additional testing would be needed if culture results were positive. Additionally, because of the potential for bacteria to be cleared after catheter removal,[6] urine samples might best be collected a few days after a catheter is removed for a more definitive evaluation. Further studies, including cost analyses, are warranted before any definitive recommendation can be made.

In sum, we conclude that placement of an indwelling urinary catheter in dogs for the purpose of determining urinary output is associated with a low risk of catheter-associated UTI during the first 3 days after catheter placement, provided that adequate precautions are taken for aseptic catheter placement and maintenance. In dogs that developed a catheter-associated UTI, the causative bacteria were typically common urinary tract pathogens with minimal antimicrobial resistance. The low incidence of catheter-associated UTI in the present study did not allow for identification of specific risk factors beyond the absence of antimicrobial administration. Despite this demonstrated benefit, routine prophylactic antimicrobial administration is not recommended, as results of previous studies suggests that this practice may result in UTI with resistant bacteria, and UTIs in the present study did not cause any other detectable complications. Lastly, results of the present study suggest that bacterial culture of urinary catheter tips should not be used to predict whether dogs have developed catheter-associated UTIs.

[a]ChlorHex-Q Scrub, Vedco Inc, St Joseph, Mo.
[b]Nolvasan solution, Fort Dodge Animal Health, Fort Dodge, Iowa.
[c]Dover silicone-coated latex catheter, Sherwood Medical, St Louis, Mo.
[d]Veterinary Foley catheter, Cook Australia, Queensland, Australia.
[e]Keto-Diastix, Bayer Corp, Elkhart, Ind.
[f]Media Laboratory, University of California, Davis, Calif.
[g]Sensitizer System, Radiometer America Inc, Westlake, Ohio.
[h]Excel 2000, Microsoft Corp, Redmond, Wash.

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