Dogs with neurologic urinary bladder dysfunction, severe musculoskeletal injury, or other reasons for loss of normal urinary bladder function pose management challenges. Proper urinary bladder management may require manual urinary bladder expression, intermittent cystocentesis, intermittent catheterization, or placement of an indwelling urinary catheter. Of concern is whether these practices increase the risk for UTI and, if infection develops, whether these practices are likely to promote growth of resistant bacteria. Multiple factors may influence this risk, including iatrogenic urinary tract trauma, immune status of the animal, urinary bladder dysfunction, environmental contamination, prolonged exposure to a potential source of nosocomial bacteria, and catheter management protocols.1-3

In most cases, dogs with IVDD severe enough to require surgical decompression of the spinal cord also have urinary bladder dysfunction.1,4-6 Manual urinary bladder expression can be difficult in these dogs because of upper motor neuron urinary bladder dysfunction or obesity, and manual expression can be painful for a dog that has recently undergone spinal surgery. Residual urine after expression is a potential source of infection, and inadequate urinary bladder decompression can lead to overflow incontinence and detrusor atony.7,8 Intermittent catheterization is a viable option in male dogs, but not female dogs. Neurologic dysfunction of the urinary bladder, intermittent urinary bladder catheterization, and placement of indwelling urinary catheters all have the potential to increase the risk of UTI.1,2,9-15 Thus, the combination of these factors in dogs with loss of urinary bladder function secondary to IVDD might create a high risk of infection. The prevalence of UTI in dogs with indwelling catheters was 52% in 1 study.9 Despite the potential risks, intermittent catheterization may be a reasonable alternative for management of dogs with urinary bladder dysfunction, but that duration of catheterization should be minimized and indiscriminate antimicrobial administration to dogs with indwelling urinary catheters should be avoided. (J Am Vet Med Assoc 2007;231:893-899)
such concerns, management of dogs undergoing surgery for IVDD with indwelling urinary catheters is attractive because it decreases stress associated with manual expression and intermittent catheterization, provides a time-saving effect on management of these dogs, and is possibly less uncomfortable for the dogs. It is not known how methods for urinary bladder management, specifically indwelling catheters, affect occurrence of UTI or antimicrobial resistance of the causative pathogens in these dogs. In particular, it is not clear how bladder management affects UTI in dogs with urinary bladder dysfunction secondary to IVDD compared with other dogs managed with indwelling urinary catheters or dogs with UTIs not managed with catheters.

The objective of the study reported here was to determine frequency of UTIs in catheterized dogs that had IVDD or diseases other than IVDD and compare urine bacterial culture and susceptibility testing results with results for noncatheterized dogs with UTIs. We hypothesized that dogs with IVDD managed with indwelling urinary catheters are not more likely to develop UTIs than are dogs managed with indwelling urinary catheters for other reasons. The duration of urinary catheterization increases the risk for UTI, the frequency of multiple bacterial isolates would be greater for dogs with indwelling urinary catheters than for noncatheterized dogs with UTI, and antimicrobial resistance would be greater in dogs managed with indwelling urinary catheters than in dogs with UTI that were not managed with indwelling urinary catheters.

**Materials and Methods**

Medical records for dogs treated from 1999 through 2000 were used for the study. Inclusion criteria for catheterized dogs with IVDD (group 1) were that the dog must have been hospitalized for surgery for IVDD, received an indwelling urinary catheter managed with a closed catheter system, and had a urine sample collected via cystocentesis and submitted for bacterial culture and susceptibility testing after catheter removal. Catheterized dogs with diseases other than IVDD (ie, hospitalized for treatment of neurologic disease other than IVDD or for treatment of severe musculoskeletal conditions [group 2]) must have received an indwelling urinary catheter managed with a closed catheter system and have had a urine sample collected via cystocentesis and submitted for bacterial culture and susceptibility testing after catheter removal. Dogs with UTI and no catheters (group 3) must have had bacterial growth from a urine sample collected via cystocentesis and submitted for bacterial culture and susceptibility testing, been ambulatory, not had urinary catheters placed before or during treatment, not have been hospitalized, and not undergone surgery for any problem at the time of the urine sampling.

**Data collection**—Information collected for all dogs included signalment, clinical problem and history, concurrent medication administered, and identity and antimicrobial susceptibility of bacterial species isolated. A UTI was defined as quantitative growth of at least 1 bacterial species at a concentration > 1,000 CFUs/mL from a urine sample collected via cystocentesis. History of UTI referred to any previous episode of UTI that the owner recalled or that was noted in the medical record. Antimicrobial use referred to any antimicrobial administered prior to urine sampling for bacteriologic culture during treatment for the current problem. This included antimicrobials administered by the referring veterinarian and antimicrobials administered in relation to surgery and during urinary catheterization. Antimicrobial resistance patterns for bacterial isolates were based on the minimum inhibitory concentration of the bacteria. Antimicrobials were considered effective if the mean urine concentration of the antimicrobial was 4 times the minimum inhibitory concentration for a bacterial species.

Bacterial isolates were tested for susceptibility to 1 of 7 antimicrobial panels, depending on the bacterial genus and species, as determined by the microbiological laboratory. All panels contained antimicrobials of 3 major classes commonly used for treating UTIs: β-lactams, aminoglycosides, and quinolones (minimum of 14 antimicrobials tested/panel [Appendix]). For examination of antimicrobial resistance, the proportion of antimicrobials tested to which a bacterium was resistant was calculated for each bacterial species isolated. Duration of catheterization was recorded for catheterized dogs. All data were entered into a database.

**Statistical analysis**—Distributions of categoric data were described by proportions, and distributions of numeric data were described by median, mode, and range. Frequency distributions of categoric data were compared across groups by use of the Fisher exact test (2 tailed) when there were ≤ 3 categories and cells contained < 5 observations. The χ² test was used for data with ≥ 4 categories. A 0.5 correction was used for cells with 0 observations if categories could not be collapsed. For significant tests with > 2 categories, ad hoc comparisons were performed between 2 selected categories by use of the Fisher exact test (2 tailed). The distributions were first evaluated across all 3 groups and then across catheterized (groups 1 and 2) and noncatheterized dogs (group 3).

Numeric data were compared across 3 groups by use of the Kruskal-Wallis test. Ad hoc comparisons were performed by use of the Kruskal-Wallis method. The Mann-Whitney test was used for 2-group comparisons.

Logistic regression was used to evaluate possible associations between exposure factors (age, sex, reason for catheterization [group], duration of catheterization, history of previous UTI, administration of corticosteroids, and administration of antimicrobials) and the occurrence of UTI in groups 1 and 2. The logistic regression model with the best fit was selected on the basis of the difference in the deviance. For the model with the best fit, those variables for which the 95% confidence interval of the estimated odds ratios excluded 1.0 were considered significant, and the odds ratios were reported as the measure of association with UTI. Computer software was used for the analysis. For all comparisons, P ≤ 0.05 was considered significant.

**Results**

**Signalment**—Dogs that met inclusion criteria included 105 dogs in group 1, 42 dogs in group 2, and 99 dogs in group 3. Among dogs with known sex, there...
were 50 males (22 sexually intact and 28 neutered) and 53 females (7 sexually intact and 46 spayed) in group 1; 18 males (7 sexually intact and 11 neutered) and 19 females (3 sexually intact and 16 spayed) in group 2; and 18 males (10 sexually intact and 8 neutered) and 61 females (13 sexually intact and 48 spayed) in group 3. There was a significantly ($P < 0.001$) different distribution of males and females among groups; the proportion of female dogs was higher than the proportion of male dogs in group 3, but not in group 1 or 2.

Among dogs with known age, median age was 5 years (mode, 4 years; range, 2 to 15 years) for group 1 dogs ($n = 104$), 5 years (mode, 2 years; range, 0.3 to 14 years) for group 2 dogs ($42$), and 7 years (mode, 10 years; range, 0.3 to 10 years) for group 3 dogs ($95$). Group 3 dogs were significantly ($P = 0.004$) older than group 1 and 2 dogs.

Among dogs with known body weight, median weight was 7.7 kg (16.9 lb; mode, 6.8 kg [14.9 lb]; range, 2.7 to 50.0 kg [5.9 to 110 lb]) for group 1 dogs ($n = 104$); 18.2 kg (40 lb; mode, 18.2 kg; range, 4.5 to 53.2 kg [9.9 to 117 lb]) for group 2 dogs ($42$); and 19.3 kg (42.5 lb; mode, 17.7 kg [38.9 lb]; range, 1.0 to 71.4 kg [2.2 to 157.1 lb]) for group 3 dogs ($95$). Group 1 dogs weighed significantly ($P < 0.001$) less than dogs in groups 2 and 3.

Among dogs of known breed, the most common breeds in group 1 were Dachshund ($51/105$ [48.6%]), Pekingese ($8/105$ [7.6%]), Beagle ($6/105$ [5.7%]), and Cocker Spaniel ($6/105$ [5.7%]). All other breeds were represented by ≤ 2 dogs; there were 9 mixed-breed dogs (8.6%). The most common breeds in group 2 were Labrador Retriever ($6/42$ [14.3%]), Beagle ($3/42$ [7.1%]), and Gordon Setter ($3/42$ [7.1%]). All other breeds were represented by ≤ 2 dogs. The most common breeds in group 3 were Labrador Retriever ($11/99$ [11.1%]), Cocker Spaniel ($5/99$ [5.1%]), Doberman Pinscher ($4/99$ [4%]), Golden Retriever ($4/99$ [4%]), Rottweiler ($4/99$ [4%]), Miniature Schnauzer ($4/99$ [4%]), Boxer ($3/99$ [3%]), Irish Wolfhound ($3/99$ [3%]), Pomeranian ($3/99$ [3%]), and Poodle ($3/99$ [3%]). All other breeds were represented by ≤ 2 dogs.

Clinical problems and history—All group 1 dogs had IVDD and underwent surgical decompression of the spinal cord. Among dogs with known lesions, 5 of 104 (4.8%) had cervical lesions and 99 of 104 (95.2%) had thoracolumbar lesions. Group 2 dogs had a variety of problems, the most common being pelvic fracture (20/42 [47.6%]). The most common concurrent problem for group 3 dogs was hyperadrenocorticism (6/99 [6.1%]). Among dogs with available information, 7 of 88 (7.9%) group 1 dogs had a history of previous UTI and 81 of 88 (92.1%) did not. Two of 27 (7.4%) group 2 dogs had a history of previous UTI, and 25 of 27 (92.6%) did not. Sixteen of 88 (18.2%) group 3 dogs had a history of previous UTI, and 72 of 88 (81.8%) did not. The frequency of previous UTI was significantly ($P = 0.03$) higher in noncatheterized dogs (group 3), compared with that in catheterized dogs (groups 1 and 2).

History of medications—Among catheterized dogs with available information, 25 of 67 (37.3%) group 1 dogs had received antimicrobials and 42 of 67 (62.7%) had not. Thirty-one of 42 (73.8%) group 2 dogs had received antimicrobials and 11 of 42 (26.2%) had not. Ninety eight of 103 (95.1%) group 1 dogs had received corticosteroids and 5 of 103 (4.9%) had not. Fifteen of 41 (36.6%) group 2 dogs had received corticosteroids and 26 of 41 (63.4%) had not.

Catheterization—Dogs were catheterized for a median of 3 days (mode, 2 days; range, 1 to 33 days) in group 1 ($n = 105$) and 4 days (4 days; 1 to 11 days) in group 2 ($42$). Duration of catheterization was significantly ($P < 0.001$) longer for group 2 dogs.

Bacteriologic culture results—Bacteriologic culture of urine samples resulted in bacterial growth of at least 1 species for 44 of 105 (41.9%) group 1 dogs, 23 of 42 (54.8%) group 2 dogs, and 99 of 99 (100%) group 3 dogs. There was no significant difference ($P = 0.2$) in the frequency of urinary tract infection between groups 1 and 2 dogs. Growth of 2 bacterial species occurred in 10 of 44 (27.3%) samples from group 1 dogs, 3 of 23 (13.0%) samples from group 2 dogs, and 10 of 99 (10.1%) samples from group 3 dogs. Growth of 3 bacterial species occurred in 2 of 44 (4.5%) samples from group 1 dogs, 2 of 23 (8.7%) samples from group 2 dogs, and 2 of 99 (2.0%) samples from group 3 dogs. There was no significant difference in the frequency of bacterial species isolated between groups 1 and 2 dogs ($P = 0.143$) or between catheterized (groups 1 and 2) and noncatheterized dogs (group 3; $P = 0.08$). There were 57 bacterial isolates from group 1 dogs, 30 isolates from group 2 dogs, and 113 isolates from group 3 dogs (Table 1). There was a significant ($P < 0.001$) difference in frequency distribution of bacterial species isolated between catheterized (groups 1 and 2) and noncatheterized (group 3) dogs. Escherichia coli ($\leq 0.001$) and Pseudomonas spp ($P = 0.024$) were significantly more frequent in noncatheterized dogs than in catheterized dogs.

Table 1—Frequency (No. [%]) of isolates of various bacterial species from catheterized dogs with (IVDD) and without IVDD (Non-IVDD) and ambulatory dogs with a confirmed UTI. Some dogs had more than 1 isolate; isolates listed as “other” were isolated only once from each affected dog.

<table>
<thead>
<tr>
<th>Group</th>
<th>Escherichia coli spp</th>
<th>Enterobacter spp</th>
<th>Enterococcus spp</th>
<th>Klebsiella spp</th>
<th>Proteus mirabilis spp</th>
<th>Pseudomonas aeruginosa spp</th>
<th>Staphylococcus spp</th>
<th>Streptococcus spp</th>
<th>Other spp</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVDD</td>
<td>17 (29.8)</td>
<td>9 (15.8)</td>
<td>3 (5.3)</td>
<td>3 (5.3)</td>
<td>1 (1.8)</td>
<td>7 (12.3)</td>
<td>7 (12.3)</td>
<td>6 (10.5)</td>
<td></td>
<td>57</td>
</tr>
<tr>
<td>Non-IVDD</td>
<td>9 (30.0)</td>
<td>5 (16.7)</td>
<td>1 (0.4)</td>
<td>3 (10.0)</td>
<td>2 (6.7)</td>
<td>3 (10.0)</td>
<td>6 (6.7)</td>
<td>1 (0.4)</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>UTI</td>
<td>63 (55.8)*</td>
<td>1 (0.9)*</td>
<td>6 (5.3)</td>
<td>12 (11.5)*</td>
<td>2 (1.8)</td>
<td>0*</td>
<td>7 (6.2)</td>
<td>14 (12.4)</td>
<td></td>
<td>113</td>
</tr>
</tbody>
</table>

*Significantly ($P = 0.05$) different, compared with IVDD and non-IVDD groups.
more frequent in group 3 dogs, whereas Enterobacter spp (P ≤ 0.001) and Staphylococcus spp (P ≤ 0.001) were significantly more frequent in catheterized dogs (groups 1 and 2). There was no significant difference (P = 0.8) in the frequency distribution of bacterial species isolated between groups 1 and 2.

For the most common bacterial species, the proportion of isolates with antimicrobial resistance was not significantly different among groups (Table 2). Antimicrobial susceptibility panel 3 (Table 3) was most frequently used to determine antimicrobial resistance, and the proportion of bacterial isolates tested did not differ significantly (P = 0.08) between catheterized (groups 1 and 2) and noncatheterized (group 3) dogs.

Risk of UTI—For catheterized dogs, the likelihood of UTI was examined for the effects of group (group 1 vs group 2), sex (male vs female), age (years), duration of catheterization (days), history of previous UTI (yes vs no), administration of corticosteroids (yes vs no), and administration of antimicrobials (yes vs no). The model of best fit included sex, age, duration of catheterization, and administration of antimicrobials. Group, history of UTI, and administration of corticosteroids were eliminated from the model because these factors were not associated with outcome. Age, duration of catheterization, and administration of antimicrobials had significant associations with occurrence of UTI. Accounting for other factors in the model, increasing age by 1 year increased the odds of UTI by 20% (OR, 1.20; 95% CI, 1.03 to 1.28), lengthening the duration of catheterization by 1 day increased the odds of UTI by 27% (OR, 1.27; 95% CI, 1.05 to 1.55), and administration of antimicrobials increased the odds of UTI by 454% (OR, 4.54; 95% CI, 1.83 to 11.27).

### Table 2—Median proportion (mode, range) of antimicrobials tested for which bacterial species had resistance. Bacteria were isolated from the urine of catheterized dogs with (IVDD) and without IVDD (Non-IVDD) and ambulatory dogs with a confirmed UTI.

<table>
<thead>
<tr>
<th>Group</th>
<th>Escherichia coli</th>
<th>Enterobacter spp</th>
<th>Enterococcus spp</th>
<th>Klebsiella spp</th>
<th>Proteus mirabilis</th>
<th>Pseudomonas aeruginosa</th>
<th>Staphylococcus spp</th>
<th>Streptococcus spp</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVDD</td>
<td>0.055</td>
<td>0.43</td>
<td>0.05</td>
<td>0.27</td>
<td>0.14</td>
<td>0.595</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>No. of dogs</td>
<td>26</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Non-IVDD</td>
<td>0.09</td>
<td>0.29</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.47</td>
<td>0.095</td>
<td>0</td>
</tr>
<tr>
<td>No. of dogs</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>UTI</td>
<td>0.05</td>
<td>0.55</td>
<td>0.19</td>
<td>0.13</td>
<td>0.14</td>
<td>0.50</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>No. of dogs</td>
<td>71</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>13</td>
<td>3</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

NM = No mode.

### Table 3—No. (%) of bacteria tested via various antimicrobial panels; bacteria were isolated from urine of catheterized dogs with (IVDD) and without IVDD (non-IVDD) and ambulatory dogs with a confirmed UTI.

<table>
<thead>
<tr>
<th>Group</th>
<th>Panel 1</th>
<th>Panel 2</th>
<th>Panel 3</th>
<th>Panel 4</th>
<th>Panel 5</th>
<th>Panel 6</th>
<th>Panel 7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVDD and non-IVDD</td>
<td>4 (4.7)</td>
<td>8 (9.4)</td>
<td>38 (44.7)</td>
<td>20 (23.5)</td>
<td>1 (1.2)</td>
<td>7 (8.2)</td>
<td>7 (8.2)</td>
<td>85 (100)</td>
</tr>
<tr>
<td>UTI</td>
<td>0</td>
<td>20 (18.0)</td>
<td>64 (57.6)</td>
<td>9 (8.1)</td>
<td>3 (3.6)</td>
<td>14 (12.6)</td>
<td>111 (100)</td>
<td></td>
</tr>
</tbody>
</table>

### Discussion

In this study, dogs that had surgery for IVDD and that were catheterized were not more likely to have a UTI than were dogs catheterized for other reasons. Importantly, the likelihood of a UTI significantly increased with duration of catheterization by 27% for each day of catheterization. These findings supported our hypotheses and results of other studies in which duration of catheterization was associated with development of UTI. Factors that predispose to bacterial colonization during catheterization include mucosal damage during catheter insertion and maintenance, contamination of the catheter and urine with organisms during catheter placement, the close proximity of the urethra to fecal sources of potentially virulent microorganisms, the catheter providing a conduit for bacterial movement into the urinary bladder either externally from the catheter exit site or internally from the urine collection system, retrograde flow of urine from the collection system to the urinary bladder, residual urine, urinary bladder dysfunction, normal to alkaline urine pH, low urine osmolality, and immune compromise. Controlling these factors and minimizing the duration of catheterization when possible should be considered in any dog requiring indwelling catheterization.

Sex was not associated with the likelihood of UTI in catheterized dogs. Previous studies also found that sex was not associated with prevalence of UTI in catheterized dogs. In contrast, there were significantly more females than males in the group 3 dogs, consistent with the literature that suggests a higher prevalence of naturally occurring UTIs in females. In catheterized dogs, increasing age by 1 year increased the risk of developing a UTI by 20%, which concurred with findings of another report. Age and stress can
have negative effects on immune function and might, therefore, hinder effective clearance of bacteria that enter the urinary system via catheterization. Furthermore, the potential for disturbances in local immune response and normal function of the urinary bladder might also be influenced by age such that older dogs develop diseases that have an association with UTIs. We were not able to elucidate concurrent problems from the medical records that might have confounded associations with age.

Administration of antimicrobials in the treatment period, whether intermittent or continuous, increased the likelihood of UTI by 454% in catheterized dogs. The present study did not distinguish dogs that had received antimicrobials during catheterization from those that had received perioperative or preoperative administration prior to referral. Therefore, no conclusion based on the timing of antimicrobial administration can be made. Antimicrobials administered prophylactically during urinary catheterization procedures to dogs and humans do not prevent UTI, although they may decrease prevalence of infection in the short term. Results of the present study emphasize this point, and there is no indication for prophylactic antimicrobial administration as part of an indwelling catheter management protocol. Furthermore, other studies have shown that more infections with antimicrobial-resistant bacteria occur if antimicrobials are given during catheterization. The increased likelihood of UTI associated with antimicrobial administration was, however, surprising, compared with results of other studies. In 1 study of dogs undergoing surgery for IVDD, the prevalence of UTI was significantly less in dogs that received preoperative administration of antimicrobials. However, none of the dogs had indwelling urinary catheters and some dogs had normal urinary bladder function, which make a direct comparison with the dogs of the present study difficult. Commensal organisms are thought to have a possible protective effect with regard to urinary bladder infection; antimicrobial administration may alter commensal populations and predispose to infection. Although the effect of antimicrobial use was examined in light of other factors in our study, antimicrobial use may have been confounded by additional factors not examined. For example, concurrent diseases (eg, perineuritis dermatitis and diabetes) may have been the indication for antimicrobial administration and may have been the actual risk factor for UTI. Without knowledge of all possible confounding factors, the exact explanation of the association between antimicrobial administration and UTI cannot be elucidated.

Administration of corticosteroids was not associated with the likelihood of UTI in catheterized dogs. One hundred thirteen of the 144 (78.5%) catheterized dogs had received corticosteroids prior to urinary catheter placement. A previous study found a similar result in dogs with IVDD and UTI. However, dogs that receive corticosteroids for a prolonged period have increased risk of UTI. Most dogs with catheters in the present study were given a short course of corticosteroids that may not have had the same effect on immune status, healing capabilities, and alteration in urodynamics that long-term administration of corticosteroids might have had. Interestingly, the most common concurrent disease in the group 3 dogs was hyperadrenocorticism. This concurred with other reports of increased prevalence of UTIs in dogs with hyperadrenocorticism, which is likely related to the long-term effects of corticosteroids such as urinary dilution and reduced urinary bladder immunity.

Another finding in the present study was the difference in distribution of bacterial species isolated from the urine. Dogs that were catheterized were not more likely to have infections with multiple bacterial species than were noncatheterized dogs, contrary to our hypothesis. Escherichia coli was the most common isolate in all groups, which was consistent with other reports. However, the proportions of organisms isolated in each group in the present study differed; E coli and Proteus spp were significantly more frequent in noncatheterized dogs, and Enterobacter spp and Staphylococcus spp were significantly more frequent in catheterized dogs. The group 3 dogs did not have indwelling urinary catheters, were not hospitalized, and were therefore less likely to develop nosocomial infections. Enterobacter spp and Staphylococcus spp are common isolates from hospitalized dogs that develop nosocomial infections and more frequent isolation of these organisms in the catheterized dogs likely reflected their hospitalized state. Furthermore, staphylococci are common commensal skin and periurethral isolates, and infection may be the result of contamination during the catheterization procedure or ascending infection. Therefore, the difference in frequency of isolation was likely a reflection of how and where infections were introduced.

An important finding was the lack of difference in bacterial antimicrobial resistance between catheterized dogs and noncatheterized dogs, contrary to our hypothesis. Antimicrobial resistance was quite minimal for some bacterial species. As expected, enteric bacteria had more antimicrobial resistance. This result was encouraging because other studies evaluating antimicrobial resistance have detected a higher proportion of resistant organisms associated with urinary catheterization. Many dogs in those studies were critically ill and required prolonged hospitalization, often in intensive care units. In contrast, most of the dogs evaluated in our study were not critically ill and likely were not in intensive care for prolonged periods, nor were they catheterized for prolonged periods. However, if prolonged urinary catheterization is necessary, limiting that animal’s exposure to the intensive care unit may be prudent. Prospective evaluation of dogs managed in the intensive care unit, compared with those managed elsewhere, would be necessary to determine any association.

Overall, 48% of catheterized dogs had a UTI. Results of the present study support the short-term use of indwelling catheters in dogs with urinary bladder dysfunction or difficulty urinating normally. Minimizing the duration of catheterization is important; however, when infection develops, isolates do not appear intractable to medical management. Nevertheless, of major interest is determining whether catheterization increases the risk of developing a UTI, compared with other urinary management techniques. Answering this question would require a controlled clinical trial.

b. SAS, version 9.1, SAS Institute, Cary, NC.
Appendix

Panels of antimicrobials tested against bacterial isolates from 147 catheterized and 99 noncatheterized dogs with UTI.

<table>
<thead>
<tr>
<th>Panel 1</th>
<th>Panel 2</th>
<th>Panel 3</th>
<th>Panel 4</th>
<th>Panel 5</th>
<th>Panel 6</th>
<th>Panel 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>Amikacin</td>
<td>Amikacin</td>
<td>Amikacin</td>
<td>Amikacin</td>
<td>Amikacin</td>
<td>Amikacin</td>
</tr>
<tr>
<td>Cephalothin</td>
<td>Amoxicillin</td>
<td>Ampicillin</td>
<td>Ampicillin</td>
<td>Amikacin</td>
<td>Amikacin</td>
<td>Amox-Clav</td>
</tr>
<tr>
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<td>Amoxicillin</td>
<td>Ampicillin</td>
<td>Ampicillin</td>
<td>Cephalothin</td>
<td>Carbenicillin</td>
<td>Amoxicillin</td>
</tr>
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<td>Carbenicillin</td>
<td>Amp-Sub</td>
<td>Cephalothin</td>
<td>Chloramp</td>
<td>Carbenicillin</td>
<td>Carbenicillin</td>
</tr>
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<td>Cefazolin</td>
<td>Chloramp</td>
<td>Cefoxime</td>
<td>Cefoxime</td>
<td>Cefoxime</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>Cefoxitin</td>
<td>Cefoxitin</td>
<td>Cefoxime</td>
<td>Cefoxime</td>
<td>Cefoxime</td>
<td>Cefoxime</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>Ceftriaxone</td>
<td>Ceftriaxone</td>
<td>Clarythromycin</td>
<td>Gentamicin</td>
<td>Clindamycin</td>
<td>Chloramphenicol</td>
</tr>
<tr>
<td>Imipenem</td>
<td>Cefuroxime</td>
<td>Cefuroxime</td>
<td>Clindamycin</td>
<td>Cephalothin</td>
<td>Cephalothin</td>
<td>Cefuroxime</td>
</tr>
<tr>
<td>Oxacillin</td>
<td>Cefuroxime</td>
<td>Cefuroxime</td>
<td>Clindamycin</td>
<td>Cefoxitin</td>
<td>Cefoxitin</td>
<td>Ciprofloxacin</td>
</tr>
<tr>
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<td>Mezlocillin</td>
<td>Cephalothin</td>
<td>Gentamicin</td>
<td>Cefoxitin</td>
<td>Cefoxitin</td>
<td>Ciprofloxacin</td>
</tr>
<tr>
<td>Rifampicin</td>
<td>Tetracycline</td>
<td>Nitrofurantoin</td>
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References