Outcomes in dogs with uroabdomen: 43 cases (2006–2015)

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OBJECTIVE
To determine the rate of and factors associated with survival to hospital discharge in dogs with uroabdomen.

DESIGN
Retrospective case series.

ANIMALS
43 dogs with uroabdomen confirmed at 2 veterinary teaching hospitals from 2006 through 2015.

PROCEDURES
Medical records were reviewed and data extracted regarding cause and location of urinary tract rupture, serum creatinine concentration and other variables at hospital admission, and outcomes. Variables were tested for associations with survival to hospital discharge.

RESULTS
Urinary tract rupture occurred in the urinary bladder (n = 24 [56%]), urethra (11 [26%]), kidney (2 [5%]), ureter (1 [2%]), both the urinary bladder and kidney (1 [2%]), and undetermined sites (4 [9%]). Rupture causes included traumatic (20 [47%]), obstructive (9 [21%]), and iatrogenic (7 [16%]) or were unknown (7 [16%]). Surgery was performed for 37 (86%) dogs; the defect was identified and surgically corrected in 34 (92%) of these dogs. Hypotension was the most common intraoperative complication. Nineteen dogs had information recorded on postoperative complications, of which 10 (53%) had complications that most often included death (n = 3) and regurgitation (3). Thirty-four (79%) dogs survived to hospital discharge. Dogs with intraoperative or postoperative complications were significantly less likely to survive than dogs without complications. Serum creatinine concentration at admission was not associated with survival to discharge.

CONCLUSIONS AND CLINICAL RELEVANCE
A high proportion of dogs with uroabdomen survived to hospital discharge. No preoperative risk factors for nonsurvival were identified. Treatment should be recommended to owners of dogs with uroabdomen. (J Am Vet Med Assoc 2018;252:92–97)

Uroabdomen is the presence of urine within the peritoneal cavity and may arise from disruption anywhere along the urinary tract, including the kidneys, ureters, urinary bladder, or intra-abdominal portion of the urethra. In dogs, the urinary bladder is the most common site of rupture, followed by the urethra.1,2 Kidney and ureteral rupture are uncommonly reported.1

Uroabdomen in dogs is most commonly attributable to trauma, with vehicular or other blunt-force trauma predominating.1,3,4 Injury to the urinary tract has been identified in 39% of dogs with pelvic fractures,2 although a more recent study5 revealed uroabdomen in only 3.6% of dogs with pelvic fractures. Iatrogenic trauma associated with urethral catheterization is another common cause of urinary tract rupture in cats and dogs.1,3,4 Uroabdomen may also occur after surgery involving any intra-abdominal portion of the urinary tract and has been identified in 16% of cats undergoing surgery for ureteral calculi.6 Nontraumatic causes of uroabdomen include overdistension caused by obstruction of the urethra with calculi or neoplasia, urinary bladder expression, and cystocentesis.1,5

A diagnosis of uroabdomen is typically confirmed through biochemical analysis of peritoneal effusion samples. This test has 100% sensitivity and specificity for diagnosing uroabdomen when 2 of the following are true: the effusion creatinine concentration is > 4 times that of the upper reference limit for serum creatinine concentration, the ESCR is > 2, or the ESKr is > 1.4.7 Additional diagnostic tests used to confirm the presence of uroabdomen include the use of contrast imaging, such as contrast cystourethrography for distal urinary tract lesions or excretory urography for proximal urinary tract lesions.1,3,4,8 Diagnosis may also be achieved by identification of a rupture at the time of surgery.

Treatment for uroabdomen is dependent on the location and severity of the urinary tract dis-
rupture. Many dogs with uroabdomen have had severe trauma, have evidence of hypovolemic shock, and are considered medical emergencies at the time of initial evaluation. Additionally, these patients are at increased risk of developing life-threatening hyperkalemia. Aggressive IV fluid administration, urinary diversion, and treatment specifically targeting hyperkalemia are often necessary to stabilize these patients prior to surgery. Dogs with concurrent urinary tract infections will have septic peritonitis in addition to uroabdomen, which warrants rapid surgical intervention. Surgical treatment is often required for definitive repair of the urinary tract defect. Dogs and cats with small urethral or cystic tears have been successfully treated by maintaining an indwelling urinary catheter with a closed collection system until the defect has healed.

After exclusion of cats that were euthanized for nonmedical reasons, a 27.3% mortality rate was identified for cats with uroabdomen in a retrospective case series. Mortality rates for cats and dogs receiving treatment for urethral rupture, with or without uroabdomen, are reportedly 25.4% and 22.2%, respectively. In a study involving dogs with experimentally induced uroabdomen, the mortality rate was 78%; no surgical closure of the defect nor urinary diversion was performed. Nonsurvivors died between 2 and 4 days after the defect was created, emphasizing the need for rapid diagnosis and treatment. To the authors’ knowledge, no studies have been conducted to evaluate the rate of survival to hospital discharge for dogs with spontaneous uroabdomen. The objective of the study reported here was to determine the rate of and factors associated with survival to hospital discharge in dogs with spontaneous uroabdomen. The hypothesis was that serum creatinine concentration at admission would be predictive of nonsurvival.

Materials and Methods

Case selection criteria
Medical records from 2006 through 2015 from 2 veterinary teaching hospitals were retrospectively searched to identify dogs with uroabdomen confirmed by an ESR > 2, extravasation of contrast material from the urinary tract on diagnostic imaging, or surgical identification of a disruption to the urinary tract. To be included, dogs were required to have received medical or surgical treatment for uroabdomen. Dogs with incomplete medical records (lack of surgery report or clinical data confirming the presence of uroabdomen) were excluded.

Medical record review
Data extracted from the medical records included dog signalment, diagnosis of uroabdomen, location and cause of rupture, selected biochemical data, contrast imaging and surgical findings, whether preoperative urinary diversion was performed, nature of any intraoperative or postoperative complications, duration of hospitalization, and whether the dog survived to hospital discharge. For intraoperative complications, hypotension was defined as a systolic arterial blood pressure < 90 mm Hg for > 10 minutes during surgery.

Statistical analysis
The Fisher exact test and chi-squared test were used to evaluate differences in categorical data (location of rupture [kidney, ureter, urinary bladder, or urethral], cause of rupture [traumatic, iatrogenic, obstructive, or unknown], and presence of intraoperative or postoperative complications) between dogs that did and did not survive to hospital discharge. The Fisher exact test was used to evaluate the likelihood of using a peritoneal catheter at one hospital versus the other and the relationship between preoperative contrast imaging and identification of the defect at surgery. An unpaired t test (normally distributed data) and Mann-Whitney U test (nonnormally distributed data) were used to evaluate differences in continuous variables (dog age, serum creatinine concentration, and serum BUN concentration) between dogs that did or did not survive. Values of P < 0.05 were considered significant.

Results

Dogs
Forty-three dogs qualified for inclusion in the study, including 19 (44%) sexually intact males, 10 (23%) castrated males, and 14 (33%) spayed females. Breeds included Dachshund (n = 5), Dalmatian (3), German Shepherd Dog (3), Rat Terrier (3), Blue Heeler (2), Labrador Retriever (2), Mastiff (2), Shih Tzu (2), and various others (1 each); there were also 7 mixed-breed dogs.

Diagnosis of uroabdomen
The ESR was supportive of uroabdomen (ie, ESR > 2) for 26 of 29 (90%) dogs for which ESR data were available, whereas the ESKr was supportive of uroabdomen (ESKr > 1.4) for 8 of 14 (57%) dogs for which ESKr data were available. Contrast imaging was performed for 23 (53%) dogs, and results were considered diagnostic or suggestive of a urinary tract rupture for 20 (87%) of these dogs.

Ruptures
Locations of ruptures included the urinary bladder (n = 24 [56%]), urethra (11 [26%]), undetermined (4 [9%]), kidney (2 [5%]), ureter (1 [2%]), and both urinary bladder and kidney (1 [2%]). Causes of ruptures included traumatic (n = 20 [47%]), obstructive (9 [21%]), and iatrogenic (7 [16%]) or were unknown (7 [16%]).

Surgical management
Thirty-seven (86%) dogs were surgically managed, 21 (57%) of which had undergone prior contrast imaging. The defect was identified and surgically corrected in 34 (92%) of these dogs. In 3 (8%) dogs, no urinary tract defect was identified at surgery. In 1 of the 3 dogs, leakage could be seen in the area of the urethra but the
actual tear could not be identified. This dog was successfully treated by placement of an indwelling urinary catheter. In the other 2 dogs, a urinary tract defect could not be identified and the dog was euthanized or died. Necropsy of 1 of these 2 dogs revealed a urethral tear. None of the 3 dogs with unidentified urinary tract defects had contrast imaging performed before surgery. Use of preoperative contrast imaging was not significantly \((P = 0.07)\) associated with the likelihood of identifying the urinary tract defect during surgery. Dogs at one hospital were significantly \((P = 0.0001)\) more likely to have a peritoneal catheter placed before surgery \((7/16\) dogs) than those at the other hospital \((0/21\) dogs).

Intraoperative complications were recorded for 13 of 37 \((5%)\) dogs for which such information was available, including hypotension \((n = 7)\), bradycardia \((2)\), hemorrhage \((2)\), regurgitation \((2)\), and death \((2)\). Postoperative complications were recorded for 10 of 19 \((53\%)\) dogs for which such information was available, including death \((n = 3)\), regurgitation \((3)\), persistent leakage of urine \((2)\), aspiration pneumonia \((1)\), disseminated intravascular coagulation \((1)\), incisional infection leading to septic peritonitis \((1)\), urinary incontinence \((1)\), and anemia requiring blood transfusion \((1)\).

Information on postoperative urinary diversion was available for 33 \((77\%)\) dogs. A urethral catheter was placed after surgery in 19 \((58\%)\) of these dogs. The 16 dogs in this group that survived to discharge had an indwelling urethral catheter in place for a median of 4 days \((\text{range}, 1\rightarrow 13\) days). The urinary catheter was purposefully removed from 2 of these dogs on postoperative days 1 and 4, and uroabdomen was noted to recur. The urinary catheter was subsequently replaced for 5 and 8 additional days, and no additional urine leakage was noted.

Four of 33 \((12\%)\) dogs with available information had a cystostomy tube placed. In half \((2/4)\) of these dogs, the cystostomy tube had been placed because of unresolvable urethral obstruction and uroabdomen developed from breakdown of the cystostomy tube site. In 1 other dog, the tube had been placed after resolution of the uroabdomen as a means of postoperative urinary diversion. In the fourth dog, the tube had been placed as a component of stabilization prior to surgery to repair the defect in the urinary tract. For 10 \((30\%)\) dogs with available information, no postoperative urinary diversion was used.

Nine of 34 \((26\%)\) surviving dogs had a postoperative contrast imaging study performed a median of 5 days \((\text{range}, 3\rightarrow 24\) days) after medical or surgical treatment was initiated to confirm closure of the defect in the urinary tract. Results indicated no extravasation of contrast medium for any dog, suggesting successful closure of the defect.

Two of the 37 \((5\%)\) dogs that were surgically managed had septic uroabdomen, and 1 \((3\%)\) other dog developed a septicec and abdomen from a postsurgical incisional infection. In 1 dog, uroabdomen had developed 2 days after a cystotomy that yielded a positive result of microbial culture of urine. The dog was immediately taken to surgery because of suspected septic uroabdomen. The dog never developed clinical signs of septic abdomen and recovered without incident. The second dog developed septic uroabdomen after leakage from a cystostomy tube that had been placed because of an unresolvable urethral obstruction. Septic effusion was confirmed through effusion-to-serum glucose and lactate concentration ratios and a positive result of microbial culture of a urinary bladder sample that had been obtained during the first surgery 1 day previously. This dog also had aspiration pneumonia and disseminated intravascular coagulation that was successfully treated, but the dog was ultimately euthanized when the owners declined scrotal urethrostomy. The third dog with the incisional infection was treated successfully and discharged from the hospital.

Medical management

Six \((14\%)\) dogs were treated with medical management only: 5 with an indwelling urethral catheter and 1 with a urethral stent for obstructive neoplasia that led to urinary bladder rupture. In these dogs, the primary rupture was located in the urinary bladder \((n = 1)\), urethra \((1)\), or an unknown location that was suspected to be the urethra or urinary bladder \((3)\). Four dogs in this group that survived to hospital discharge had their urethral catheters in place for 3 \((n = 2)\), 4 \((1)\), and 5 \((1)\) days. In the dog with the indwelling urethral catheter in place for 4 days, uroabdomen recurred 3 days after catheter removal, and the catheter was subsequently replaced for another 8 days with a successful outcome.

Survival to hospital discharge

In total, 34 of the 43 \((79\%)\) dogs survived to hospital discharge. No difference in age was identified between dogs that survived \((\text{mean} \pm \text{SD}, 6.0 \pm 4.0\) years) and did not survive \((8.7 \pm 4.5\) years; Table 1). No significant \((P = 1.00)\) difference in survival rate was identified between dogs with rupture of the urinary bladder and those with rupture of the urethra \((P = 0.61)\) associated with survival to hospital discharge. No significant difference in serum creatinine \((P \geq 0.19)\) or BUN \((P \geq 0.17)\) concentration was identified between dogs that survived or did not survive to hospital discharge.

Twenty-nine of the 37 \((78\%)\) dogs that received surgical management and 5 of the 6 \((83\%)\) that received medical management alone survived to hospital discharge; the difference in survival rates was not significant \((P = 1.00)\). For surgically managed dogs, those with an intraoperative or postoperative complication were significantly more likely to fail to survive than dogs without complications \((P = 0.03)\). All 7 dogs with a peritoneal catheter placed before surgery survived, compared with 22 of 30 \((73\%)\) dogs with no catheter placed; however, this difference was not significant \((P = 0.31)\). The mortality rate for surgical-
ly treated dogs was 6% (1/16) at the hospital where peritoneal catheters were used and 33% (7/21) at the other hospital; however, this difference was not significant ($P = 0.10$).

Of the 9 nonsurviving dogs, causes for uroabdomen included traumatic (n = 5), obstructive (2), and iatrogenic (2). Three of these dogs died (n = 2) or were euthanized (1) during surgery. The remaining dogs died after surgery (n = 3) or were euthanized after surgery (2) or after attempted medical management (1). Dogs euthanized after surgery or medical management included 1 dog with deteriorating clinical status despite intensive management, 1 dog in which uroabdomen persisted after surgery, and 1 dog with unresolvable urethral obstruction for which scrotal urethrostomy was declined by the owners.

**Discussion**

The overall mortality rate for dogs treated for uroabdomen in the present study was 21%. This compared favorably with previously reported mortality rates for
cats treated for uroabdomen (27.3%) and cats and dogs treated for urethral rupture (25.4% and 22.2%, respectively).\textsuperscript{3,4,11} The hypothesis that serum creatinine concentration at hospital admission would be predictive of death prior to hospital discharge was rejected.

Effusion potassium concentrations were uncommonly measured in the dogs of the present study. Six dogs had an ESKr < 1.4, with 4 of these dogs having an ESCR > 2. The remaining 2 dogs had confirmation of a rupture at surgery; neither the ESCR nor the ESKr was diagnostic for uroabdomen in these 2 dogs. In 3 dogs with an ESCR < 2, the ESKr was not measured and the effusion creatinine concentration was < 4 times the upper reference limit for serum creatinine concentration. Rupture of the urinary tract was confirmed at the time of surgery in these 3 dogs. Further studies involving larger numbers of dogs are needed to determine the clinical applicability of peritoneal effusion analysis and analyte ratios for establishing a diagnosis of uroabdomen.

Sixteen dogs in the present study had surgery without prior contrast imaging. The defect in the urinary tract was successfully identified in 15 of these dogs. For the 21 dogs that received contrast imaging prior to surgery, the defect in the urinary tract was successfully identified at surgery, including the 3 dogs with contrast imaging results that were not suggestive of leakage. One of these dogs underwent surgery twice before the defect was identified. Although use of contrast imaging was not significantly associated with the likelihood of identifying the urinary tract defect during surgery, it may aid in the identification and localization of urinary tract defects and is therefore recommended prior to surgery for dogs with uroabdomen.

Overall, 5 dogs died as a result of uroabdomen or associated complications. When urine is present within the peritoneal cavity, potassium is reabsorbed across the peritoneal membrane down its concentration gradient, leading to hyperkalemia. In response, the kidneys attempt to increase excretion of potassium via the distal and collecting tubules, leading to higher concentrations within the urine, and urine continues to accumulate within the abdomen.\textsuperscript{1,11} As a result of the larger molecule size, creatinine diffuses more slowly across the peritoneal membrane than potassium, and with time, serum creatinine concentration increases. Presence of creatinine within the abdomen creates a concentration gradient that draws fluid out of the tissues and into the peritoneal cavity.\textsuperscript{9} Resultant dehydration from these fluid shifts can further exacerbate azotemia, electrolyte derangements, and hypovolemic shock. Additionally, hydrogen accumulates in the abdomen instead of being excreted through the urine, leading to development of metabolic acidosis, which is further exacerbated by dehydration and hypovolemia.\textsuperscript{1,9}

In the study reported here, median duration of indwelling urethral catheter placement after surgery was 4 days. Regrowth of urinary epithelium reportedly occurs within 7 days.\textsuperscript{10} Healing would be expected to occur more quickly with primary closure of the defect than second-intention healing owing to the proximity of the wound edges. Additionally, urethral catheters are often not required to prevent postoperative leakage in dogs that have primary closure of the defect. The decision to place a urethral catheter after surgery was not standardized in the present study, and it is possible that urethral catheters were more likely to have been placed in dogs in which primary closure was challenging.

In dogs that received medical management alone, indwelling urethral catheters were kept in place for < 7 days initially in all 4 dogs that survived. The reason for early removal of indwelling urethral catheters was unclear, but for 3 of 4 dogs, successful outcomes were achieved with urethral catheters left in place for < 7 days. These results may have been dependent on extent and location of the defect, which were not determined because these dogs were not treated surgically. The findings did not allow determination of a defined period during which all urinary tract defects healed, but they did support an ability to reestablish urinary epithelial continuity in < 7 days.

Dogs with intraoperative or postoperative complications in the present study were significantly less likely to survive to hospital discharge than dogs without complications. Inclusion of death as an intraoperative and postoperative complication may have skewed these data. No additional factors, including high serum creatinine concentration at initial evaluation, were significantly associated with outcome. Many dogs were brought for evaluation following trauma, which has the potential to cause severe, life-threatening systemic injury. It would be difficult to quantify the severity of systemic injury retrospectively; therefore, elucidation of associated risk factors was not possible.

At one hospital in the present study, peritoneal catheter drainage was more likely to have been performed prior to definitive surgical correction of uroabdomen than at the other hospital. Although the mortality rate was 6% at the hospital where peritoneal catheters were used and 33% at the other hospital, this difference was not significant, possibly owing to the small number of dogs in these calculations. Nonetheless, preoperative management of dogs with uroabdomen by placement of a peritoneal catheter appears prudent given these findings. Use of a peritoneal catheter to drain the effusion prior to surgery may allow for more effective stabilization of dogs with substantial electrolyte abnormalities. Additional research is needed to evaluate the effect of preoperative stabilization with peritoneal drainage on the rate of survival to hospital discharge in dogs with uroabdomen.

In a previous study\textsuperscript{3} of urethral rupture with or without uroabdomen in dogs and cats, only the presence of multiple traumatic injuries was significantly associated with a decreased survival rate. Similar to the results of the present study, clinico-pathologic findings in the previous study had no association with outcome. Causes of urethral rupture in the dogs
of the other study\(^5\) were similar to those identified in the present study, with blunt-force trauma predominating. Causes of uroabdomen in a study\(^a\) involving cats were also similar to those in the present study, with blunt-force abdominal trauma as the most common (50% of cats, when classified similarly to the dogs in the present study). In cats, iatrogenic causes were the second most common (34%), and obstructive causes were less common (12%).\(^4\) It is conceivable that cats would be more commonly affected by iatrogenic causes than dogs owing to their greater propensity for lower urinary tract obstruction requiring urethral catheterization.\(^4\)

Similarly, locations of urinary tract rupture in the dogs of the present study were consistent with those reported for cats with uroabdomen,\(^4\) with the urinary bladder being most common, followed by the urethra. The authors of that report\(^4\) concluded that drainage of urine from the abdomen improved stabilization, although statistical analysis of this factor was not performed. That conclusion is similar to impressions that arose from the present study, although use of a peritoneal catheter prior to surgery was not significantly associated with outcome. In cats, evaluation of ESCr and ESKr on the basis of previously reported guidelines was not always diagnostic for uroabdomen,\(^4\) similar to our findings for dogs. A potential explanation for these findings as they relate to the present study is that underlying kidney disease may alter interpretation of ESCr and ESKr values, and the presence of preexisting kidney disease is difficult to ascertain in retrospective studies. Additionally, dogs may have had > 1 type of abdominal effusion that altered the creatinine and potassium concentrations.

Another factor that was not controlled in the present study because of its retrospective nature was the method of creatinine and potassium concentration measurement. Measurement of glucose concentration in biological fluids with point-of-care devices reportedly results in a different cutoff for diagnosing septic peritonitis than measurements with biochemical analyzers.\(^15\) Evaluation of a larger number of subjects with standard measurement devices may allow for more accurate determination of ratios diagnostic for uroabdomen. An additional limitation associated with the retrospective nature of the present study was that it was not possible to standardize patient management, particularly with regard to preoperative stabilization. A prospective study of the effect of preoperative stabilization on dogs with uroabdomen is warranted.

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