Antegrade pyelography for suspected ureteral obstruction in cats: 11 cases (1995–2001)

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Objective—To determine sensitivity and specificity of radiography, ultrasonography, and antegrade pyelography for detection of ureteral obstructions in cats.

Design—Retrospective study.

Animals—11 cats.

Procedure—Medical records of cats that had radiography, ultrasonography, and antegrade pyelography performed for suspected ureteral obstructions were examined. Ultrasound-guided pyelocentesis and fluoroscopic-assisted antegrade pyelography were performed on 18 kidneys in 11 cats. Obstructive ureteral lesions were confirmed in all cats by surgical or necropsy examination. Sensitivity and specificity of survey radiography, ultrasonography, and antegrade pyelography for identification of ureteral obstructions were calculated. Surgical or necropsy findings were used as the standard for comparison.

Results—All cats were azotemic. Mean ± SD serum creatinine and BUN concentrations were 10.2 ± 6.1 and 149 ± 82 mg/dL, respectively. Fifteen of 18 ureters were found to be obstructed at surgery or necropsy. Sensitivity and specificity were 60 and 100% for radiography and 100 and 33% for ultrasonography, respectively, in identification of ureteral obstructions. Leakage of contrast material developed in 8 of 18 kidneys during antegrade pyelography and prevented diagnostic interpretation in 5 of 18 studies. For the 13 diagnostic studies, specificity and sensitivity were 100% by use of the antegrade pyelography technique. Correct identification of the anatomic location of the ureteral obstruction was obtained in 100% of diagnostic antegrade pyelography studies and in 60% of radiography or ultrasonography studies.

Conclusions and Clinical Relevance—Antegrade pyelography can be a useful alternative in the diagnosis and localization of ureteral obstructions in azotemic cats, although leakage of contrast material may prevent interpretation of the study. (*J Am Vet Med Assoc* 2003;222:1576–1581)

Early diagnosis and treatment of ureteral obstruction is essential to limit the degree of irreversible injury in the affected kidney.[1,2] Experimental evidence suggests that decreased **glomerular filtration rate** (GFR) associated with early ureteral obstruction progresses rapidly to irreversible renal injury after 6 days, unless the obstruction is relieved.[3-5] However, incorrect identification or localization of obstructive lesions must be avoided because of potential complications associated with inappropriate ureteral surgery. Adequate ureteral opacification is a particular concern in animals with decreased renal function, as the efficacy of standard IV urography is dependent on a number of factors such as renal blood flow, GFR, and renal tubular osmolality.[6] In addition, systemic administration of contrast medium may decrease GFR, further exacerbating renal injury.[7,8] Contrast medium-induced nephropathy is the third most common cause of hospital-acquired acute renal failure in humans and continues to develop despite the use of contrast agents with lower osmolality.[7,9] The primary factor associated with contrast medium-induced nephropathy is preexisting renal insufficiency.[7] As a result, safe, sensitive, and specific diagnostic methods are required to aid the surgeon in planning appropriate treatment.

Antegrade pyelography has been used in the diagnosis and localization of ureteral obstructions in dogs and cats.[10,11] Antegrade pyelography provides good contrast medium filling of the ureter with minimal risk of contrast medium-induced nephropathy, because systemic administration of contrast medium is avoided.[12] Antegrade pyelography may be suited for imaging of patients with preexisting renal insufficiency.[12] A report[13] of ureteral obstruction in cats described successful use of abdominal ultrasonography and IV urography for characterization of the lesions. However, results of antegrade pyelography have only been reported in 2 cats.[11]

The purpose of the study reported here was to determine sensitivity and specificity of survey radiography, abdominal ultrasonography, and antegrade pyelography in the identification of ureteral obstructions in cats. Surgical or necropsy findings were used as the standard for comparison. Accuracy in localization of the obstruction for each technique was also determined. Our hypotheses were that antegrade pyelography was a highly specific and sensitive technique for diagnosing ureteral obstruction in azotemic cats and that few complications would be involved with application of the technique.

Criteria for Selection of Cases

Medical records of cats that had radiography, abdominal ultrasonography, and antegrade pyelography for suspected ureteral obstruction at the University of California, Davis, from January 1, 1995, through June 1, 2001, were reviewed. Cats that had either surgical or necropsy confirmation of diagnosis and localization of obstruction were included in the study.

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Procedures

Details of breed, sex, age, clinical signs, duration of clinical signs, initial BUN and serum creatinine concentrations, results of imaging studies (radiography, ultrasonography, IV urography, and antegrade pyelography), surgical or necropsy findings, and complications associated with antegrade pyelography were obtained from the medical records.

Ultrasonographic[a] examination of the entire abdomen was performed on all cats before antegrade pyelography was performed. Kidneys were imaged in the longitudinal and transverse planes to evaluate renal architecture and degree of dilatation of the renal pelvis. Ureters were evaluated for evidence of dilatation or for hyperechoic, shadowing lesions suggestive of mineralized calculi. Cystocentesis was performed, and urine samples were submitted for bacteriologic culture and cytologic analyses. Ultrasonographic images were recorded on videotape and via a multiformat camera.

After induction of general anesthesia, cats were placed in dorsal recumbency on the fluoroscopy table and stabilized by sandbags placed lateral to the abdominal and caudal thoracic walls. Fluoroscopic imaging and survey radiographs of the abdomen were obtained to assure proper radiographic technique and patient positioning. Ultrasonographic examination of the renal pelvis and evaluation of the collecting system of the kidney were repeated and used to locate a suitable approach to the kidney for antegrade pyelography. A ventrolateral approach to the kidney was used to avoid interference from a gas-filled intestine. The kidney was stabilized by use of firm pressure applied to the transducer for imaging in the longitudinal plane. A 25-gauge, 2.5-inch spinal needle was introduced into the renal cortex, perpendicular to the capsule, and advanced into the renal pelvis during ultrasonographic guidance (**Fig 1**). The stylet of the spinal needle was removed, and a small-volume (1 mL) extension set was attached to the spinal needle. Depending on the degree of dilatation of the renal pelvis, 1 to 2 mL of urine was aspirated from the renal pelvis for bacteriologic culture and cytologic evaluation. An equal volume of ionic, iodinated contrast material[b] was introduced into the renal pelvis during fluoroscopic imaging in multiple small boluses as the operator of the syringe subjectively assessed resistance to injection. Bolus injections of contrast material were repeated until adequate ureteral opacification was achieved, as determined by fluoroscopy. Hemorrhage into the renal pelvis was suspected if a filling defect appeared during fluoroscopic imaging of injection of contrast material. After administration of contrast material, the needle was withdrawn, and the kidney was imaged by fluoroscopy. Ureteral peristalsis was identified, with the aid of fluoroscopy, immediately after needle removal. Ventrodorsal and lateral abdominal radiographs were taken, and the kidney was imaged by ultrasonography to evaluate for perirenal fluid indicating hemorrhage, leakage of contrast material, or urine. Fluoroscopy was repeated at regular intervals for an additional 10 to 15 minutes, and another set of abdominal radiographs was obtained. All ultrasonographic and radiographic images were reviewed by a board-certified radiologist.

Figure 1—Ultrasonographic image of a kidney in a cat with suspected ureteral obstruction. Notice placement of a spinal needle (arrows) in the renal pelvis for antegrade pyelography.

Confirmation of the diagnosis and localization of the obstructions were performed during exploratory surgery or at necropsy. In all cats, surgery or necropsy was performed immediately following antegrade pyelography. Kidneys and ureters were examined and palpated for an obstructive lesion. Patency of affected ureters was investigated by passing a single strand of 5-0 polypropylene suture through the ureteral lumen from the urinary bladder to the kidney.

Statistical analyses—Sensitivity, specificity, and **95% confidence intervals (CIs)** were determined for identification of ureteral obstructions by survey radiography, ultrasonography, and antegrade pyelography by use of the efficient-score method.[14] Identification of the obstruction during surgery or necropsy was designated as the standard for comparison. At necropsy, the ureteral obstruction was identified as proximal, middle, or distal. Survey radiographic findings were considered positive for identification of an obstruction if a radiopaque calculus was identified. Radiographic localization of the obstruction was determined by the level at which the radiopaque calculus was located. Subjective abdominal ultrasonography findings were considered to be positive for identification of ureteral obstruction if moderate to severe dilatation of the renal pelvis and hydroureter were detected. Ultrasonographic localization of the level of ureteral obstruction was determined by the length of ureteral dilatation and identification of a hyperechoic focus indicating a ureteral calculus, when present. Antegrade pyelography findings were considered positive for ureteral obstruction if dilatation of the renal pelvis or ureter, focal narrowing of the ureter, or absence of opacification of the distal ureter was identified (**Fig 2**). Localization of the obstruction by antegrade pyelography was determined by the level at which opacification of the ureter was attenuated.

Results

Mean ± SD age for the 11 cats was 7.3 ± 3.8 years. Six of 11 cats were neutered males, and 5 were spayed females. Affected breeds included domestic shorthair (8 cats), Siamese (1), Persian (1), and Tonkinese (1). Clinical signs of illness included vomiting (6 cats),

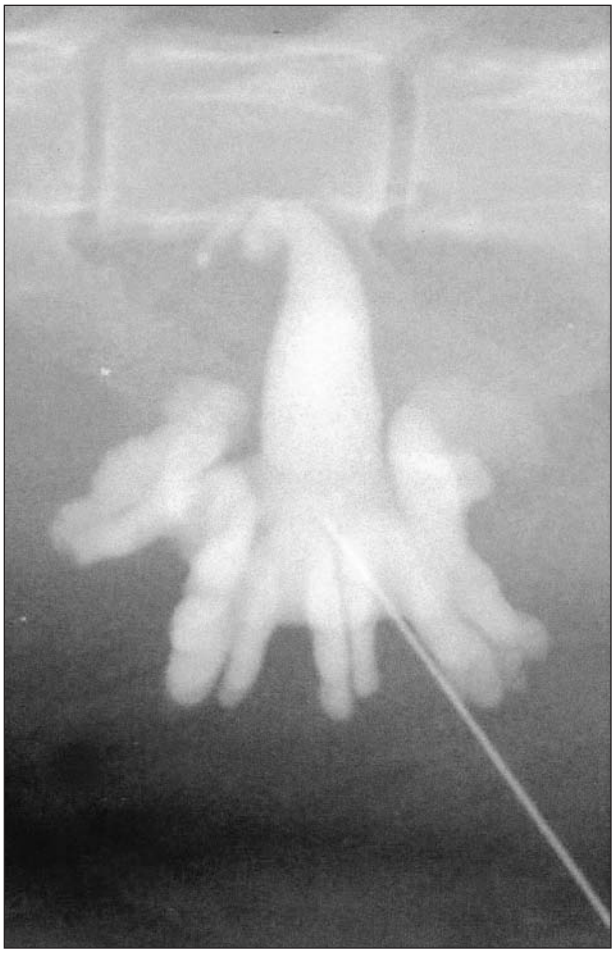

Figure 2—Lateral radiographic view of a kidney in a cat following antegrade pyelography. Notice the renal pelvis and proximal portion of the ureter are dilated. A filling defect in the ureter indicates an obstruction.

anorexia (5), weight loss (4), lethargy (4), anuria (3), and polyuria and polydypsia (1). Duration of clinical signs before examination ranged from 24 hours to 6 months. Nine of 11 cats had no history of problems related to the urinary tract. One cat had successful renal allograft transplantation 6 months before examination but had recently developed anorexia and lethargy. Clinical signs in 1 cat began 24 hours after ovariohysterectomy.

All cats were azotemic. Mean ± SD initial BUN and serum creatinine concentrations were 149 ± 82 mg/dL (reference range, 18 to 33 mg/dL) and 10.2 ± 6.1 mg/dL (reference range, 1.2 to 2.2 mg/dL), respectively.

Urine samples were collected via cystocentesis or pyelocentesis in all cats and submitted for bacteriologic culture and susceptibility testing in 7 cats. No bacteria were identified on bacteriologic culture of the urine of the 7 cats.

Survey radiography and abdominal ultrasonography preceded antegrade pyelography in all cats. Intravenous urography was performed in 2 of 11 cats but resulted in inadequate opacification of the ureters and was considered nondiagnostic. Intravenous urography was not performed in 9 of 11 cats because of concerns regarding systemic administration of contrast material to cats with preexisting renal insufficiency and moderate to severe azotemia (9 cats) and anuria (3).

Survey radiographs were available for all 11 cats. Unequal kidney size was noted in 6 of 11 cats. Ureteral obstructions were correctly diagnosed by identification of radiopaque calculi in 9 of 15 affected ureters. Three of 6 ureters were correctly identified as unobstructed on the basis of a lack of identification of radiopaque calculi. Sensitivity and specificity for identification of ureteral obstruction by use of survey radiographs were 60 (CI, 33 to 83%) and 100% (CI, 31 to 100%), respectively. Multiple calculi were found in 5 of 7 cats. Correct localization of an obstruction was achieved for 9 of 15 ureters.

Abdominal ultrasonography was performed in all 11 cats. Moderate to severe dilatation of the renal pelvis was detected in 17 of 18 kidneys in 10 cats (unilaterally in 3 cats and bilaterally in 7 cats), and ureteral obstruction was suspected in all affected kidneys. Abdominal ultrasonography correctly identified 15 of 15 obstructed ureters but correctly identified only 1 of 3 unobstructed ureters. Sensitivity and specificity for identification of ureteral obstruction by abdominal ultrasonography were 100 (CI, 75 to 100%) and 33% (CI, 18 to 100%), respectively. Dilatation of the proximal ureter was associated with dilatation of the renal pelvis in 13 of 17 kidneys. Dilatation of the distal ureter was not detected in any cats. Hyperechoic foci with shadowing suggestive of calculi were correctly identified in 5 of 10 ureters affected by ureterolithiasis. Location of the obstruction in the ureter was correctly identified in 9 of 15 affected ureters.

Antegrade pyelography was performed in 18 kidneys (unilaterally in 4 cats and bilaterally in 7 cats). Results of antegrade pyelography were considered to be of diagnostic quality for 13 of 18 attempted studies. In these 13 ureters, antegrade pyelography correctly identified a ureteral obstruction in 12 ureters, and 1 ureter was correctly identified as nonobstructed. For the 13 diagnostic studies, sensitivity and specificity for identification of ureteral obstruction by antegrade pyelography were 100 (CI, 70 to 100%) and 100% (CI, 55 to 100%), respectively. In addition, antegrade pyelography correctly identified the location of the obstruction in all 12 obstructed ureters.

Surgical intervention was pursued in 10 of 11 cats. If an intraluminal obstruction of a ureter was identified during surgery, a ureterotomy was performed, and patency of the remaining ureter was confirmed by passing a strand of 5-0 polypropylene suture distally to the urinary bladder and proximally to the kidney through the ureterotomy site. If no obstructive lesion could be identified on visual examination and palpation, a cystotomy was performed, and 5-0 polypropylene suture was passed from the urinary bladder to the renal pelvis to determine the level of obstruction, if any, in affected ureters. Proximal to mid-ureteral obstructions were managed by use of bilateral ureterotomy (6 ureters) or unilateral ureterotomy (4) and primary closure via standard microsurgical techniques.[11] Nephrotomy was performed in 2 kidneys to remove calculi that were causing intermittent obstruction at the uretero-pelvic junction but that could not be removed via pyelotomy.

Bilateral neoureterocystostomy was performed in 1 cat to resolve bilateral obstruction of the distal ureters caused by a ligature placed during surgery for ovariohysterectomy. Renal allograft nephrectomy and retransplantation were performed in 1 cat. Exploratory surgery was performed in 1 cat because of clinical signs and imaging results that indicated ureteral obstruction. During surgery, suture was passed inside the ureter from the trigone area of the urinary bladder to the kidney via a ventral cystotomy; however, no ureteral obstruction was detected. One cat was euthanatized at the request of the owners after diagnostic tests were completed.

Ureteral obstructions were identified at surgery or necropsy in 15 of 18 ureters in 10 of 11 cats (bilateral obstructions were identified in 5 cats). Causes of obstruction in these cats were unilateral (4 cats) or bilateral calcium oxalate ureterolithiasis (3), bilateral mucus plug (1), bilateral ureteral ligation during ovariohysterectomy (1), and allograft ureteral stenosis following renal transplantation (1). In 3 cats, results of antegrade pyelography were nondiagnostic; however, ultrasonographic findings of moderate to severe renal pelvic dilatation indicated that 3 additional ureters may have been obstructed. Each of these ureters was confirmed patent during surgery via retrograde passage of 5-0 polypropylene suture material from the trigone area of the urinary bladder to the renal pelvis. In 2 of these cats, ultrasonographic examination before surgery identified bilateral renal pelvic dilatation, but only unilateral obstructions were found at surgery. The third cat had only 1 kidney and was anuric at hospital admission. Examination of renal biopsy specimens taken during surgery revealed chronic lymphoplasmacytic and neutrophilic tubulointerstitial nephritis, presumably a result of primary renal insult.

Overall, complications associated with antegrade pyelography developed in 8 of 18 studies in 7 of 11 cats. The most common complication encountered was leakage of contrast material from the retroperitoneal space or renal pelvis caused by needle puncture, preventing proper filling of the affected ureter with contrast material (**Fig 3**). Leakage of contrast material developed in 8 of 18 studies, causing nondiagnostic results in 5 of 18 studies. Nondiagnostic studies resulted from leakage of contrast material from the renal pelvis secondary to inadvertent needle puncture in 3 kidneys and from capsular leakage at the site of needle puncture in 2 kidneys. Complete opacification of the ureter was obtained in 3 of 8 studies, because leakage of contrast material was minimal and isolated to the subcapsular space. One cat required surgery for repair of an iatrogenic laceration to the renal pelvis. In 7 of 8 cats, iatrogenic leakage from the urinary tract resolved without surgery. Subcapsular hemorrhage was noted during surgery in 6 of 18 kidneys. Hemorrhage into the renal pelvis was noted during antegrade pyelography in 1 kidney and resolved without evidence of secondary obstruction.

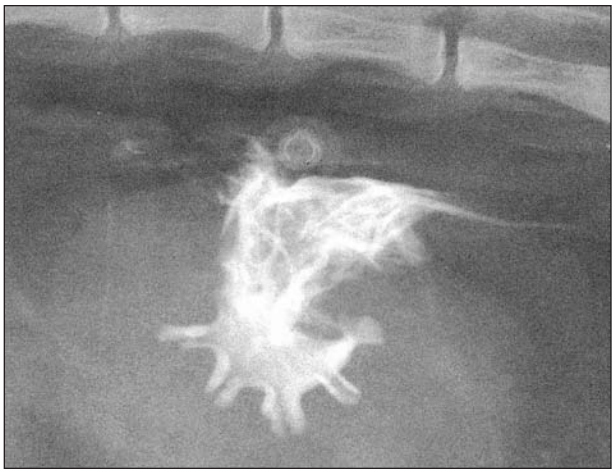

Figure 3—Lateral radiographic view of a kidney in a cat following antegrade pyelography. Notice leakage of contrast material because of inadvertent laceration of the renal pelvis.

Discussion

Advances in diagnostic and microsurgical techniques have allowed successful management of ureteral obstruction in cats, although there are a limited number of reports in the literature.[13,15] Despite technologic advances, diagnosis of ureteral obstruction remains challenging. Ureteral colic that may lead to early diagnosis of unilateral obstructive lesions in humans is rarely reported in animals. On the contrary, clinical signs that lead to diagnosis of ureteral obstruction in cats are often related to bilateral renal lesions and subsequent uremia.[10,13] Azotemia was detected in all cats in our study and in 9 of 11 cats in another study.[13] Formulating a diagnostic plan for metabolically unstable cats with ureteral obstruction requires special consideration. The ideal diagnostic test would be noninvasive, rapid, highly sensitive and specific, and would pose no risk to the cat.

Standard diagnostic tests, such as noncontrast radiography, are only useful in identification of radiopaque obstructive lesions, and interpretation is often inhibited by superimposed organs. In our study, radiopaque uroliths were correctly identified in 9 of 15 obstructed ureters, and obstructions in 3 cats without radiopaque calculi were not detected by use of noncontrast radiography. Because of the number of ureters that were obstructed by nonradiopaque structures (2 ureteral ligations, 2 mucus plugs, and 1 stricture), survey radiography had a relatively low (60%) sensitivity in detecting ureteral obstructions. Nonradiopaque obstructions may be overrepresented in this study, as antegrade pyelography may have been more likely to be performed if no radiographic findings were apparent. In a study of feline calcium oxalate urolithiasis, ureteroliths and nephroliths were correctly identified via noncontrast radiography in 8 of 10 cats.[13] Other nonspecific radiographic signs of obstructive disease include renomegaly or unequal kidney size. Unequal kidney size was identified in 6 of 11 cats in our study. Differential diagnoses for renomegaly in cats include dilatation of the renal pelvis, lymphoma, perinephric pseudocysts, polycystic kidney disease, and feline infectious peritonitis.[16] On the basis of results of our study, radiographic abnormalities, such as radiopaque calculi or renal asymmetry, should be pursued by use of complementary imaging techniques, particularly

when azotemia is identified in the affected cat. These findings may indicate a postrenal obstructive lesion requiring rapid intervention.

Intravenous urography offers several advantages over noncontrast radiography. The excretory urogram provides information related to renal vasculature, size and shape of the kidneys, and the renal collecting system.[17] Use of iodinated contrast material allows identification of nonradiopaque obstructive lesions that may remain undetected on survey radiographs. Subjective interpretation of IV urography may provide qualitative assessment of renal function,[18,19] although poor opacification of the renal collecting system does not necessarily imply irreversible renal injury.

Disadvantages are associated with IV urography. Although complications are rare, IV administration of iodinated contrast material may result in hypotension, anaphylactic shock, or acute renal failure.[7,20] The mechanism of this renal injury is related to a combination of direct tubular cytotoxicity and renal ischemia.[20] Although several reports[17,19] indicate that azotemia is not a contraindication for administration of iodinated contrast material, studies[21,22] performed in humans have identified renal insufficiency as the major risk factor in contrast medium-induced nephropathy. Another disadvantage of IV urography is the inability to obtain a diagnostic study of the renal collecting system in an oliguric or anuric cat. Several cats in our study were severely azotemic and oliguric or anuric. Concerns regarding efficacy and risk of IV urography in this group of cats frequently resulted in selection of other diagnostic methods, such as ultrasonography and antegrade pyelography.

Ultrasonography is a noninvasive, rapid method for examination of the kidneys and ureters in dogs and cats that does not require sedation, ionizing radiation, or the administration of contrast materials.[23] Ultrasonographic examination has been found to be superior in characterizing parenchymal lesions of the kidney, compared with radiographic techniques.[24] Although ultrasonography is the standard technique for examination of suspected acute ureteral obstruction in humans, the specificity and sensitivity of ultrasonography in diagnosis of ureteral obstruction has been questioned.[25] Ultrasonography is also operator-dependent, and accuracy of diagnosis may vary among institutions. Dilatation of the renal pelvis is the primary abnormality detected in association with postrenal obstruction, although this finding is not specific for obstructive disease and may also represent pyelonephritis or polyuria secondary to fluid diuresis. Moreover, 30% of obstructed kidneys in humans had no dilatation of the renal pelvis in the early stages of disease.[26] All cats with ureteral obstructions in our study had moderate to severe dilatation of the renal pelvis on ultrasonographic examination. This may be because the diagnosis was made in late stages of the disease after azotemia developed. Alternatively, the criteria for inclusion of cats in this study (those that had antegrade pyelography and surgical or necropsy confirmation of ureteral obstruction) may have selected for cats with renal disease in which surgery was warranted. Despite these selection criteria, ureteral obstruction was not confirmed during surgery in 2 kidneys that had moderate to severe dilatation of the renal pelvis on ultrasonographic examination; results of antegrade pyelography were nondiagnostic for these 2 kidneys because of leakage of contrast material. Results of ultrasonography suggested that ureteral obstruction was unlikely on the basis of mild dilatation of the renal pelvis of 1 cat. Consequently, ultrasonography had high sensitivity (but low specificity) in identifying advanced ureteral obstruction. When used alone, ultrasonography may lead to inappropriate surgical intervention in cats with nonobstructive disease.

Localization of the ureteral obstruction by use of ultrasonography was correct in 9 of 15 affected ureters. Cats had only proximal to mid-ureteral dilatation detected, regardless of the location of the obstruction, suggesting that dilatation begins proximally and progresses towards the site of the lesion. This makes localization of the level of obstruction difficult, particularly in obstructions that develop quickly. In addition, radiography is superior to ultrasonography in detection and characterization of uroliths,[27] which were the most common cause of ureteral obstruction in our study. This further contributed to the difficulty in localizing obstructive lesions by use of ultrasonography alone.

Antegrade pyelography has specific advantages in azotemic animals.[12] This technique lowers the risk of contrast medium-induced nephropathy by avoiding systemic administration of contrast material and provides excellent filling of the renal collecting system, regardless of renal function of the cat. Moreover, antegrade pyelography was found to be highly sensitive and specific in diagnosing ureteral obstruction in cats when leakage of contrast material is avoided. Unfortunately, nearly a third of the attempted antegrade pyelography studies performed in this study were nondiagnostic because of leakage of contrast material from the renal pelvis or the needle insertion site in the renal capsule. There was no evidence of urine leakage into the retroperitoneal space or abdominal cavity in any of the cats before injection of contrast material, suggesting that these complications were iatrogenic and resulted from excessive manipulation of the needle during insertion or injection of contrast material. These complications may have been related to inexperience with the technique and may decrease in frequency as more procedures are performed. Leakage of contrast material following the study was detected in 8 of 18 studies, but clinically important complications developed only in 1 cat in which iatrogenic laceration of the renal pelvis required surgical repair. Leakage was identified as a halo of contrast material confined to the subcapsular region of the kidney adjacent to the needle tract. Hemorrhage into the renal pelvis was suspected in 1 cat because of the rapid appearance of a filling defect during fluoroscopic examination of injection of contrast material. No clinical sequelae were noted in the affected cat in this study, although hemorrhage has been reported[11,28] as a cause of ureteral obstruction following antegrade pyelography or needle biopsy. Antegrade pyelography has several other disadvantages, including the need for general anesthesia and the invasive nature of the procedure. Loss of functional renal mass by use of this

technique is expected to be minimal because of the small size of the needle used for puncture, although studies indicate that renal injury depends primarily on whether a major blood vessel is interrupted and not on the size of the cannula or catheter.[10] Consequently, an alternative technique for performance of antegrade pyelography is placement of a percutaneous nephrostomy catheter. This technique would provide a way for draining urine before surgery and injecting contrast material for diagnostic studies.

The small number of cats, retrospective nature of the study, and criteria for selection may have affected sensitivity and specificity values obtained for diagnosis of ureteral obstructions in our study. The large CIs obtained suggest that sensitivity and specificity values might be inaccurate. Also, in an attempt to select those cats in which confirmation of diagnosis was obtained during surgery or necropsy, we obtained a population with a high number of true-positive diagnoses, which were moderately to severely affected. This will likely be a function of any clinical study of antegrade pyelography, because the procedure requires general anesthesia in cats and is likely to be performed when the clinician is suspicious of an obstructive lesion requiring surgical intervention. Five tests that were nondiagnostic because of leakage of contrast material during antegrade pyelography also made the assessment of the diagnostic methods used in this study difficult. Bias may have been introduced into the analysis of sensitivity and specificity, because data were analyzed for 13 ureters examined by use of antegrade pyelography, but data were included for all 18 ureters examined by radiography and ultrasonography. Despite these limitations, our study provides an opportunity for comprehensive evaluation, comparing results of diagnostic imaging with surgical findings in cats with renal disease.

[a]ATL HDT 3000 ultrasound machine, Philips Medical Systems, Best, The Netherlands.
[b]Isovue (iopamidol 41% wt/vol), Bristol-Myers Squibb Pharmaceuticals Group, New Brunswick, NJ.

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