Diagnostic imaging characteristics of ureteral pseudodiverticulosis in three dogs

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ABSTRACT: Ureteral pseudodiverticulosis is rarely reported in veterinary medicine. This case study aimed to describe the radiographic, ultrasonographic and computed tomographic findings for dogs with radiologically confirmed ureteral pseudodiverticulosis. Three dogs met the inclusion criteria. Radiographic findings included multiple small, round-shaped mineral opacities located around the periphery of the ureters (3/3), and multiple contrast medium-filled outpouchings that appeared and disappeared when the contrast medium washed in and out on intravenous excretory urography (2/3). The outpouchings were approximately 1 mm in diameter. In the ultrasonographic images, the mineral foci were located adjacent to the ureter, but not within the ureteral lumen (1/3). Contrast-enhanced CT findings were similar to those of excretory urography (2/3). Ureteral pseudodiverticulosis should be considered in the differential diagnosis for old-aged and small-breed dogs with radiopaque materials along the ureteral pathways; excretory urography or contrast-enhanced CT are recommended for a more definitive imaging diagnosis.

Keywords: computed tomography; dog; radiography; ultrasonography

Ureteral diverticula (UDs) are rare urological findings in both human and veterinary medicine. They are usually seen as incidental findings of retrograde pyelography (Socher et al. 1996). Since their original classification in human medicine (Culp 1947), human cases and related reviews have appeared regularly in the literature. However, cases have rarely been reported in veterinary medicine. In human medicine, UDs are roughly classified as follows: congenital UD, acquired UD and ureteral pseudodiverticulosis (UPD) (Holly and Sumcad 1957). Congenital UD consists of an outpouching (usually single, but sometimes multiple) of the normal ureteral wall layers. The outpouchings are round or oval, and greater than 5 mm in diameter. They result from an aberrant development of the ureteric bud. Acquired UD, also called false UD, involves mucosal protrusions through defects in the ureteral wall (Culp 1947). UPD, also called partial diverticula (Cochran et al. 1980), involves

multiple outpouchings less than 5 mm in diameter (Wasserman et al. 1985). This is in contrast with false UD, in which the outpouching is single and large. To the best of our knowledge, there are no reports of the computed tomographic (CT) features of UPD in dogs. Radiographic and sonographic findings are also scarce. The purpose of this report is to describe the radiographic, ultrasonographic, and CT features of UPD in dogs.

MATERIAL AND METHODS

Medical records were searched for dogs that were diagnosed with UPD at Chonbuk National University Animal Medical Center. The diagnosis of UPD was made based on radiologic features. Cases were included only if contrast studies were performed. The inclusion criteria for the patients were as follows: (1) multiple (at least two) and small-

sized (less than 5 mm) mineral matter located along the ureter in radiographic, ultrasonographic or CT images, (2) any contrast medium-filled foci found near the ureter in the contrast study. All decisions for subject inclusion and exclusion were made by all the authors together. The authors included two senior veterinarians with over 10 years of experience in veterinary radiology and four small-animal interns. For each case, signalment, history, clinical findings on physical examination, haematology and serum biochemistry were recorded.

Lateral and ventrodorsal abdominal plain radiographs were obtained for all three dogs (HF-525VET, Ecoray, Seoul, Republic of Korea). Intravenous excretory urograms were obtained for two dogs (dogs 1 and 2). For each excretory urogram, a bolus of the contrast medium (Iohexol at 600 mg/kg (Omnipaque 300, 300 mg/kg), GE Healthcare AS, Oslo, Norway) was injected into the cephalic vein. Then, serial abdominal radiographic images were obtained at 0, 5, 20, 40, 60 and 120 minutes. Contrast-enhanced CT (CECT) scans were performed in two dogs (dogs 1 and 3), using a 16-slice helical CT scanner (Alexion TSX-034A, Toshiba Medical Systems Co., Otawara Shi, Japan). Technique settings included 0.5-mm-thick slices, a pitch of 1 : 1 at 120 kVp and 200 mA, and 1-mm-thick slice reconstructions. The contrast procedure was the same as that for excretory urogram. Ultrasonography (Aplio 300, Toshiba Medical Systems Co., Otawara Shi, Japan) was conducted in one dog (dog 1).

Images were examined by two veterinarians (senior K.L. and intern S.L.). All images were reviewed using a picture-archiving and communication system (PACS; INFINITT PACS, Infinitt Healthcare Co., Seoul, Republic of Korea) on a diagnostic imaging workstation (ZALMAN, Windows 7 Enterprise K, Gyeonggi-do, Republic of Korea). The shape, size, location and number of mineral foci and contrast-filled pouches near each ureter were assessed. Any abnormalities of the kidneys, ureters and urinary bladder were recorded.

RESULTS

Signalment, clinical findings and treatment

Three dogs met the inclusion criteria: a 12-year-old spayed female mixed-breed dog weighing 4.8 kg (dog 1), a 16-year-old castrated male Shih Tzu weighing 8.1 kg (dog 2) and a 12-year-old, intact female Yorkshire terrier weighing 2.8 kg (dog 3).

Dog 1 presented to the Animal Medical Center with flank pain and in a non-ambulatory state after being attacked by a companion cocker spaniel. Bilateral ureterolithiasis and nephrolithiasis had been diagnosed. The dog had back pain on physical examination, but proprioception was normal. Spinal shock was initially diagnosed and treated, but no signs of improvement were seen. The patient continuously exhibited marked pain with poor appetite. Non-regenerative anaemia, a mild decrease in white blood cells and platelets, high C-reactive protein and toxic changes in neutrophils were revealed on serial haematology. These findings were suggestive of chronic inflammation. Considering the chronic inflammatory status and lack of absolute proof of severe ureteral obstruction, the patient was treated in a conservative manner. The patient died of untreated underlying disease about a month after the initial presentation. Due to the client's refusal of a necropsy, no further investigation was performed. Dog 2 presented with chronic dermatitis and chronic cervical intervertebral disk disease. Treatment for both conditions was undertaken. There were no remarkable findings on the blood panel. Dog 2 had bilateral ureterolithiasis and nephrolithiasis at the time of presentation. Dog 3 was referred from a local clinic for CT scans because the dog had abdominal distension due to a focal hepatic mass and peritoneal effusion. Abdominal CT scans revealed that the hepatic mass was a heterogeneous contrast-enhanced mass measuring 4.8 cm in height and 7.9 cm in width × 7.8 cm in length, with necrotic lesions. There was no absolute evidence of metastasis, and the mass was surgically removed. Histopathologically, it was diagnosed as a biliary carcinoma. There were no significant findings from the haematology and chemistry profiles. None of the dogs exhibited urinary tract-related symptoms.

Imaging and diagnosis

In dog 1, based on the initial plain radiography, at least five to six small (1–3 mm), round-shaped mineral opacities were identified along each ureter, and particularly in the proximal portion of each ureter (Figures 1A and 1E). Differential diagnoses included ureteral calculi, dystrophic calcification, ureteral polyps and ureteral diverticula.
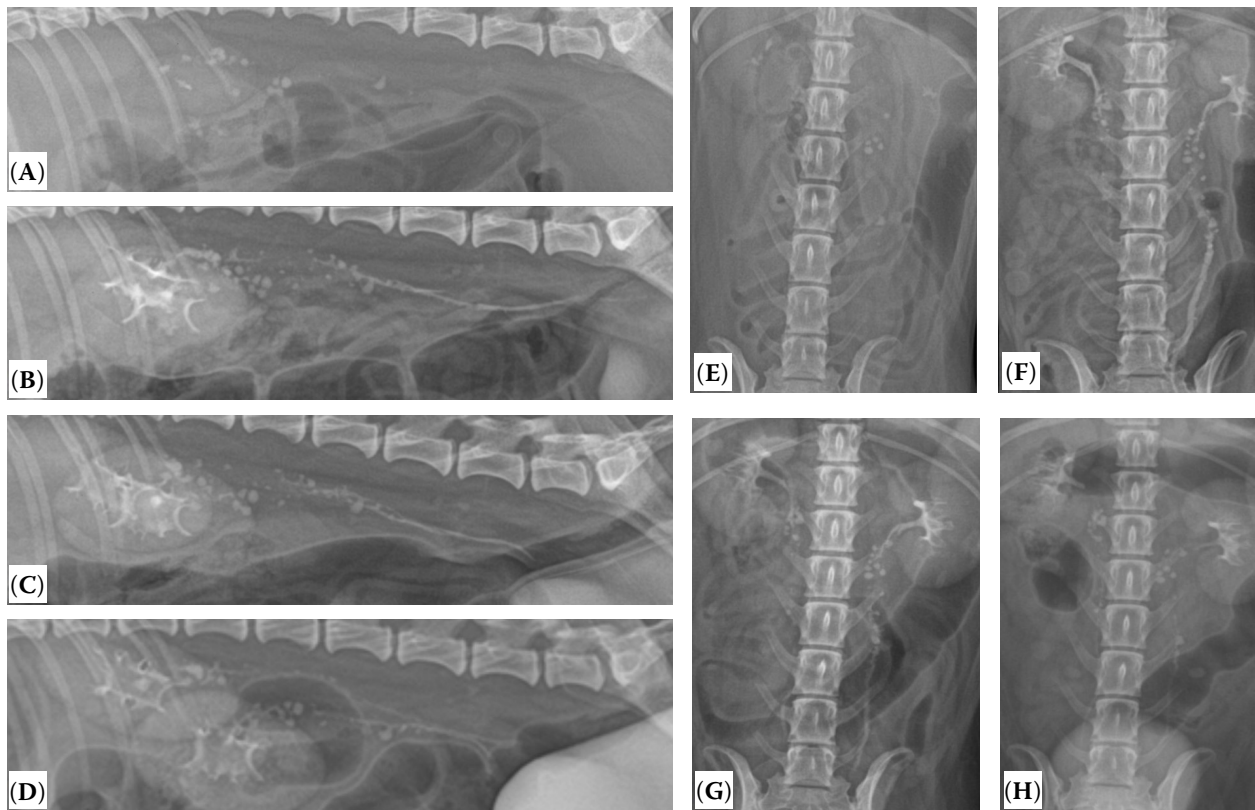
Figure 1. Right lateral and ventrodorsal radiographs of small, round-shaped mineral opacities along the bilateral ureters after intravenous excretory urography (EU) in dog 1. Firstly, plane radiographic images were obtained ((**A**) and (**E**)). Post-contrast lateral and ventrodorsal images were then taken at 5 minutes ((**B**) and (**F**)); 20 minutes ((**C**) and (**G**)); 2 hours ((**D**) and (**H**))

Ultrasonography revealed that some of the calcified foci were located along but not inside the ureters. These were round-shaped and hyperechogenic with distal shadow (Figure 2). Hence, ureteral calculi and ureteral polyps were unlikely. The excretory urogram revealed small (about 1.5 mm), round-
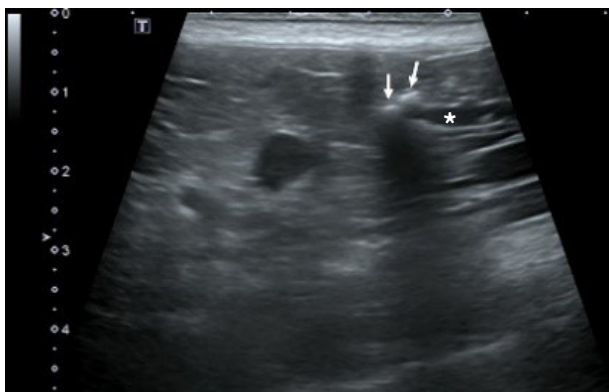

Figure 2. Sagittal sonogram of the round-shaped hyperechoic structures (white arrows) along the ureter (asterisk) in dog 1

shaped, contrast-enhanced foci along the bilateral ureters. The number of foci was about seven to 15. The contrast-enhanced foci disappeared when the contrast medium was washed out (Figure 1). Mild bilateral ureteral dilations were identified by ultrasonography and excretory urogram. CECT scans were conducted to confirm the diverticula. The CT scans were performed in lateral recumbency without general anaesthesia because the patient was cooperative. The radiopacities in the plain CT images were hyper-attenuated. As with the excretory urogram, small, contrast medium-filled pouches were found adjacent to the bilateral ureters, and these disappeared over the course of time (Figure 3).

In dog 2, there were small, round mineral opacities along the ureters in the plain radiographic images (Figure 4). These were at least 15 in number, each measuring about 1 mm in diameter. From the excretory urogram, about five to 10, small (less than 1 mm), contrast medium-filled outpouchings were identified around the entire periphery of the ureters. These slowly became empty.
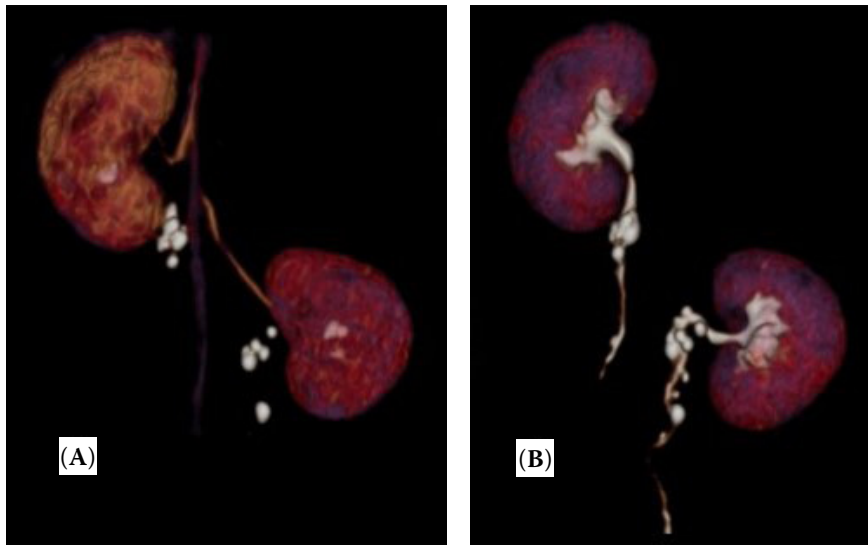
Figure 3. Pre-contrast (**A**) and post-contrast (**B**) three-dimensional reformatted computed tomographic images of ureteral pseudodiverticulosis in dog 1

In dog 3, small (1 to 3 mm) mineral foci were incidentally found near the proximal ureters on the radiographic and CECT images including three near the right ureter and one near the left ureter (Figure 5). They were identified in the ventrodorsal image and were difficult to assess clearly because of the loss of serosal detail with peritoneal effusion (associated with the hepatic mass). On abdominal
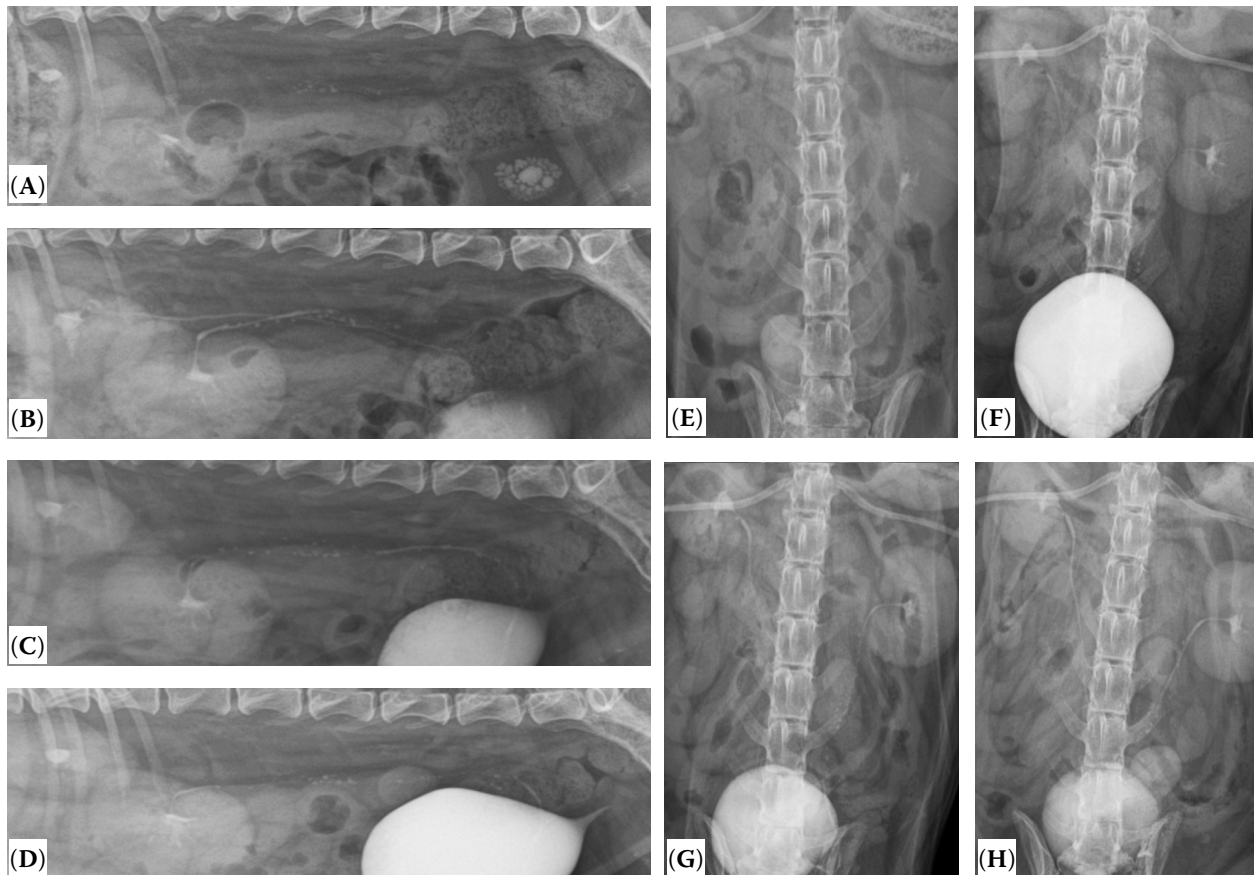

Figure 4. Right lateral and ventrodorsal radiographs of small, round-shaped mineral opacities along the bilateral ureters after intravenous excretory urography (EU) in dog 2. Firstly, plane radiographic images were obtained ((**A**) and (**E**)). Post-contrast lateral and ventrodorsal images were then taken at 5 minutes ((**B**) and (**F**)); 20 minutes ((**C**) and (**G**)); 2 hours ((**D**) and (**H**))
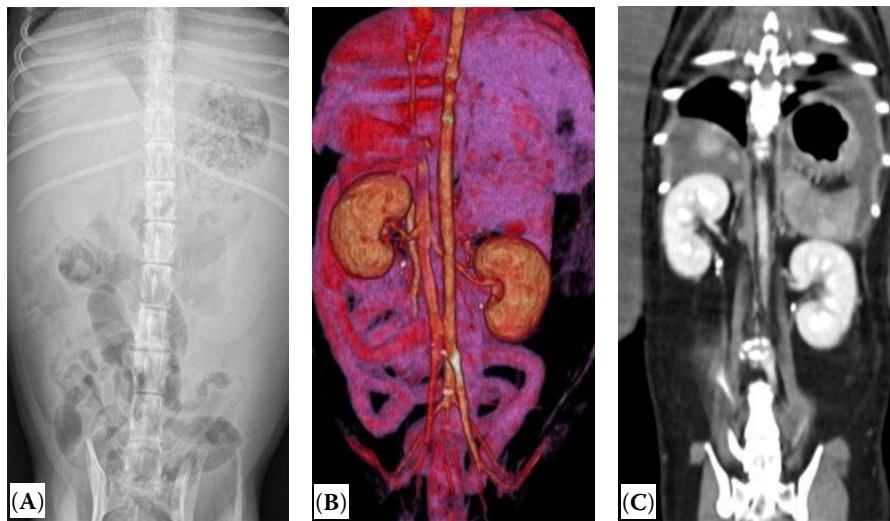
Figure 5. Ventrodorsal radiographic image (**A**), and three dimensional (**B**) and dorsal reformatted computed tomographic (**C**) images of dog 3. There were mineral foci near the bilateral ureteral pathways

CT images, the mineral foci were located immediately adjacent to each ureter.

These dogs were diagnosed with bilateral, acquired UPD with concurrent calculi based on the post-drainage images. Multiple small, and contrast medium-filled outpouchings are typical features of UPD (Holly and Sumcad 1957; Cochran et al. 1980; Wasserman et al. 1985).

DISCUSSION

To the best of our knowledge, this is the first published report describing the CT features of UPD in dogs. Based on the three dogs in this study and two dogs in a previous study (Jakovljevic et al. 1998), all dogs reported to have UPD have been over ten years of age and have been small breeds weighing less than 10 kg. These two studies show a much higher incidence in females (four dogs; three of which were spayed) than in males (one castrated dog). Each ureteral diverticulum was approximately 3 mm in diameter or less, and there were multiple diverticula in each case. The mineral foci found outside of the ureters were most likely stones in pouches, as described previously (Mori et al. 2011).

Similar to the canine patients described here, UPD is found in both ureters in about 75% of human cases, and particularly in the upper and middle third of each ureter (Wasserman et al. 1985). Although the pathogenesis is not fully understood, one attractive theory is that continued focal inflammation caused by local urine stasis results in benign epithelial changes. This leads to small intramural invaginations with elevation and thinning of the ureteral wall. The pathology may be enhanced by infection or obstruction due to stones (Wasserman et al. 1985). This theory is supported by a post-mortem study of 200 ureters in 1988 (Wasserman et al. 1988). Applying this theory to our cases, calculi in the kidneys and ureters would have triggered local urine stasis, enhancing focal (subclinical) inflammation. Resulting epithelial changes would have led to intramural crypts in the bilateral ureters. Other theories to explain UPD should also be considered. One alternative theory proposes the occurrence of ureteral diverticula through weak spots in the ureteric wall; another theory proposes an association with uroepithelial tumours (Parker et al. 1989; Tan 1995). It is difficult to rule out an association with tumours. Previous studies have shown that ureteral diverticula, especially cases with multiple diverticula, may promote tumour development (such as transitional cell carcinoma) with a latency period of about two to ten years (Wasserman et al. 1985; Kenney and Wasserman 1987; Wasserman et al. 1988; Wasserman et al. 1991). Approximately 30–46% of UPD cases are associated with urothelial malignancy (Parker et al. 1989; Wasserman et al. 1991). There is one reported human case where ten years elapsed between UPD diagnosis and the development of transitional cell carcinoma of the renal pelvis (Kenney and Wasserman 1987). The periodic, long-term follow-up of patients with UPD has been recommended in several studies (Kenney and Wasserman 1987; Parker et al. 1989; Wasserman et al. 1991; Jakovljevic et al. 1998; Chen et al. 2000). A simple, conservative treatment strategy for ureteric diverticula generally has a good prognosis in cases without clinical signs (Socher et al. 1996; Jakovljevic et al. 1998).

The blood panel performed on dog 1 showed high levels of C-reactive protein and small numbers of red and white blood cells. This reflects the inflammatory status of the patient and supports a subclinical, chronic inflammatory condition (possibly induced by one of the triggers mentioned above). However, dogs 2 and 3 had no abnormalities in their haematology and chemistry profiles.

Retrograde pyelography is the diagnostic tool of choice for UD because it allows ureteral diverticula to be distinctly delineated (Cochran et al. 1980). In contrast,excretory urogram often results in only some of the diverticula filling with contrast medium (Tan 1995). Nevertheless, in the present report, excretory urogram was easy, non-invasive and performed well for the diagnosis of UPD. The CECT images gave three-dimensional confirmation (also non-invasively) to the UPD.

One limitation of this report was the lack of histopathologic confirmation of the radiologic diagnosis of UPD due to the absence of necropsy.

In conclusion, we have reported for the first time the CT features of suspected UPD in three old-aged, small-breed dogs. UPD appears to be pathognomonic on post-contrast images, given that contrast-filled outpouchings around the periphery of both ureters prominently appeared and then disappeared after discharge of the contrast medium. UPD may be more common than expected and should be suspected whenever radiopaque materials are observed along the ureteral pathways during survey radiography. Enhanced imaging studies (EU and/or CECT) are useful and informative for accurate diagnosis and management of dogs with suspected UPD.

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