

CASE REPORT

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Surgical treatment and outcome of complete unilateral urinary tract duplication in a dog

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Abstract

Objective: To report the surgical technique and outcome for correction of complete unilateral duplication of the left urinary tract in a dog.

Animals: One 7-month-old entire male Jack Russell terrier.

Study design: Case report

Methods: A dog was referred for investigation because of urinary incontinence (UI), preputial irritation (pruritus), diphallia, and cryptorchidism. Computed tomography including urethrographic studies revealed a left duplex kidney, double ectopic left ureters, and a duplex urinary bladder comprising two halves separated by a median septum, each of which emptied into a separate urethra which coursed through separate penises. The left testis was abdominally retained. The right upper urinary tract was considered normal, and the right testis was within the scrotum. Left sided ureteronephrectomy was performed, the median bladder septum was ablated, and the left urethra was ligated. The left penis was partially amputated, and the dog was castrated.

Results: Urinary incontinence was improved but persisted after surgery. After repeat imaging, revision surgery was performed 3 months later in which the distal stumps of the (left) ectopic ureters were found to be filling with urine from the right urethra. Urinary incontinence resolved after resection of these ureteric stumps from the prostate and complete transection of the left urethra.

Conclusion: Extensive surgery with resection and correction of urinary tract duplication was successful in resolving UI in this case. Urogenital duplication should be considered a rare cause of UI. The presence of external congenital deformity (eg, diphallia) should alert clinicians to the possibility of significant concurrent internal abnormalities.

1 | INTRODUCTION

Urinary tract duplications are congenital malformations in which either the entire or part of the urinary tract is duplicated. Although there are no previous reports of complete duplication of the urinary tract in veterinary medicine, there are reported cases of duplication of

various parts of the tract including the kidney, ureter, bladder, and urethra.¹⁻¹⁶ Duplex kidney is a commonly encountered abnormality of renal development in human medicine, with an incidence of approximately 1%.¹⁷ A complete duplex kidney is defined as two separate pelvic systems that have arisen from two ureteral buds from the mesonephric duct.¹⁸ Only two cases of

duplex kidneys are described in veterinary medicine, one in a cat and one in an English bulldog.¹⁻² Ureteric ectopia has frequently been reported in veterinary medicine, and duplication of the ureters has occasionally been reported. Five cases of ureteric duplication have previously been described in dogs and one case in cats, although three of these cases of duplication were also ectopic.^{1,3-6} In human medicine, duplex kidney associated with incomplete, partial, or complete duplication of the draining ureters is referred to as a *duplex collecting system* or *duplex system*. In a duplex system, each ureter drains a separate pelvicalyceal system and opens separately into the bladder or ectopically into the urethra.¹⁸ Bladder duplication has been described in isolation in one cat and one dog.⁷⁻⁸ In one case report, bladder duplication was also reported associated with multiple anomalies including diphallia, cryptorchidism, renal hypoplasia, and bifurcation of the descending colon.⁹ Urethral duplication without associated diphallia has been described three times in veterinary medicine.¹⁰⁻¹² Diphallia (true duplication) is defined in man as the presence of two complete separate penises, each with two cavernous bodies, one urethra, and one spongiosum.¹⁹ Diphallia has been reported four times in dogs but only once in a cat^{9,13-16} and has been reported associated with other abnormalities.^{9,14,16} Bladder and urethral duplications have been reported both as sole abnormalities and in combination in man.²⁰

The most common congenital cause of urinary incontinence in dogs is ureteric ectopia, and this most commonly causes a history of intermittent or permanent urinary incontinence from birth.²¹

We present here what we believe is the first case of complete unilateral duplication of the urinary tract in a dog presenting with a history of urinary incontinence and describe the diagnostics and surgery performed together with the long-term outcome.

2 | MATERIALS AND METHODS

A 7-month-old intact male Jack Russell terrier was referred because of a 1-month history of urinary incontinence, which was worse during recumbency, and preputial pruritus. Cryptorchidism and diphallia were noted at clinical examination (Figure 1). The two penises appeared anatomically normal, although the left penis was relatively hypoplastic compared with the right penis, and the right glans penis was persistently partially protruding from the prepuce. No other abnormalities were identified during the physical examination.

Initial hematology and serum biochemistry profiles and urinalysis were unremarkable. Computed tomography (CT) of the abdomen was performed to help determine the



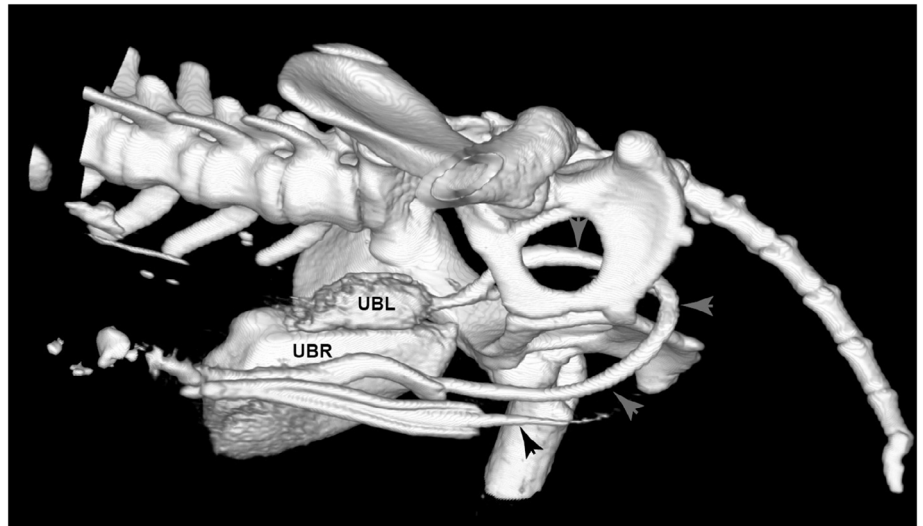
FIGURE 1 Diphallia: both penises are visible protruding from the prepuce

cause of the urinary incontinence and to screen for potential concurrent anatomical abnormalities. Computed tomographic images of pre-IV and post-IV contrast studies and retrograde CT-urethrography were evaluated. The left kidney was severely misshapen, characterized by a bilobed fluid attenuating structure with gravity dependent amorphous mineral and a thin peripheral region of contrast-enhancing parenchyma was present. There were two dilated ureter-like structures containing foci of mineral density arising from each lobe of the left kidney and extending to the level of the prostate gland (Figure 2). Two urinary bladder-like structures were also present, with one urinary bladder filling with concentrated positive contrast from the morphologically normal right kidney and ureter (Figure 3). There were also duplicated urethras and penile structures, each of which had a separate os penis. Retrograde urethrography results of the right urinary tract were unremarkable, with a patent right-sided urethra that communicated with the urinary bladder receiving positive contrast from the right ureter. Results of left-sided retrograde urethrography confirmed patency of the left urethra and communication with the left-sided urinary bladder-like structure. The left testis was cryptorchid. These findings



FIGURE 2 Computed tomographic post-IV contrast images of the abdomen: sagittal maximum intensity projection (A), dorsal (B), and transverse (C). Mineral is present within the dilated renal structures (black arrows in A). Left renal duplication with cranial (Cr) and caudal (Cd) portions (A, B). There are dilated and tortuous ureters contiguous with the cranial (arrows) and caudal (arrowheads) components of the left kidney (B). There are separate right (UBR) and left (UBL) urinary bladders and duplicated penises each containing an os penis (double arrows). C, Mineral is present within the dilated renal structures (black arrows C)

FIGURE 3 Volume rendered computed tomographic of left-sided retrograde urethrography after prior right-sided retrograde urethrography. Image viewed from ventral-left side. There is positive contrast delineating the left urethra (gray arrows) and filling the left urinary bladder (UBL). There is residual positive contrast from a prior right-sided urethrogram (black arrow) and positive contrast filling the right urinary bladder (UBR)



were compatible with complete left-sided duplication of the upper and lower urinary tracts and left-sided ureteral ectopia (Figure 4).

The planned surgical treatment was ureteronephrectomy of the left duplex kidney, ablation of the bladder septum, left phallus removal, and castration. The dog was premedicated with methadone (0.2 mg/kg IV); general anesthesia was induced with alfaxalone (2 mg/kg IV) and maintained with isoflurane in oxygen after intubation. A continuous rate infusion of fentanyl was given (5 µg/kg/minute IV), and meloxicam (0.2 mg/kg IV) was administered preoperatively. Amoxicillin-clavulanic acid (20 mg/kg IV) was administered perioperatively and every 2 hours during the procedure. The dog was positioned in dorsal recumbency and clipped from the xiphoid process to the caudal pelvic symphysis. The dog's right penis was catheterized with a 6-French (Fr) 55-cm Foley catheter before

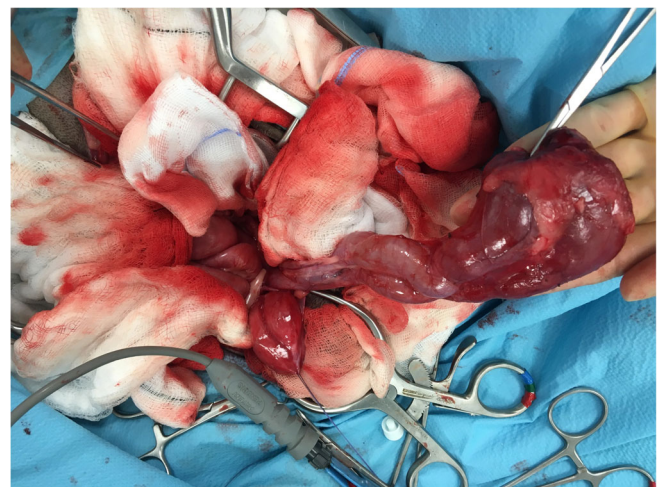


FIGURE 4 Intraoperative photograph of the left double ureters originating from duplex kidney structure

the surgical area was aseptically prepared for surgery. A midline incision was made extending from the xiphoid to the pubic brim (parapreputially). Abdominal exploration confirmed the presence of a fluid distended structure (duplex kidney) within the left retroperitoneum. Two distended ureters were seen twisting around each other; they coursed caudally before inserting into the left aspect of the prostate gland (Figure 5). The left retained testis was found adjacent to the bladder. The right kidney was grossly normal, and the right ureter inserted into the bladder trigone in a normal anatomical position. The bladder was mildly indented along its ventral midline, and this corresponded to the midline septum seen on imaging. The remainder of the abdominal exploration was within normal limits. The left duplex kidney and ureters were mobilized from their retroperitoneal attachments. The left duplex kidney had a normal vascular pedicle, and the left renal artery and vein were double ligated with 2 M polyglactin 910 (Vicryl; Ethicon, Somerville, New Jersey). The left ureters seemed to share a common medial wall. The ureters were ligated together

approximately 2 to 3 mm proximal to their prostatic insertion. The left kidney and ureters were then excised. A ventral cystotomy was then performed with the incision just to the right of the palpable bladder septum. This septum was visualized through the cystotomy incision, and the septum was then excised at its base. This united the two bladder compartments but created a narrow mucosal defect, which was then closed with 1.5 M glycomer 631 (Biosyn; Medtronic, Watford, United Kingdom) to appose the mucosal linings from the two previously separate bladder cavities. The cystotomy incision was then routinely closed with 1.5 M glycomer 631 (Biosyn; Medtronic). The left preprostatic urethra was ligated with a circumferential suture of 2 M polypropylene (Prolene; Ethicon) but was not divided. The left retained testis was ligated and removed, and the right descended testis was ligated and removed via a separate prescrotal incision. The abdomen was lavaged with sterile saline solution (0.9% NaCl) and routinely closed. The left hypoplastic penis was amputated by using standard technique with a Penrose drain to retract the right penis away from the surgical field.²² The right penis remained within the prepuce after amputation of the left penis. The dog recovered from anesthesia uneventfully and remained hospitalized for monitoring, analgesia, and supportive care. A 6-Fr 55-cm Foley urethral catheter that had been placed preoperatively was maintained for 24 hours postoperatively. Treatments included methadone (0.1–0.2 mg/kg IV, with dose dependent on pain score) and IV fluid therapy with isotonic crystalloids (fluid rate of 2 mL/kg/hour). Postoperative antibiotics (amoxicillin clavulanic acid 20 mg/kg every 12 hours) were continued for 5 days because of concerns about potential undetected urinary tract infection at the time of surgery and until the results of a urine culture that had been collected at the time of surgery were available. After the urinary catheter was removed, normal urination was observed. An ultrasonographic examination of the bladder was performed 48 hours postoperatively and confirmed that the bladder was functioning as a single compartment with only mild mucosal thickening visible at the site of the previous septum. The dog was discharged 2 days after the surgery, and skin sutures were removed by the referring veterinarian 10 days postoperatively. The intraoperative urine culture results were negative.

3 | RESULTS

Postoperative reexamination occurred 1 month after the surgery. At this time, the owner reported only one episode of urine dribbling. At physical examination, it was possible to extrude the right penis but not the remnant of the left penis. At a second postoperative examination 2 months postoperatively, the owners reported worsening

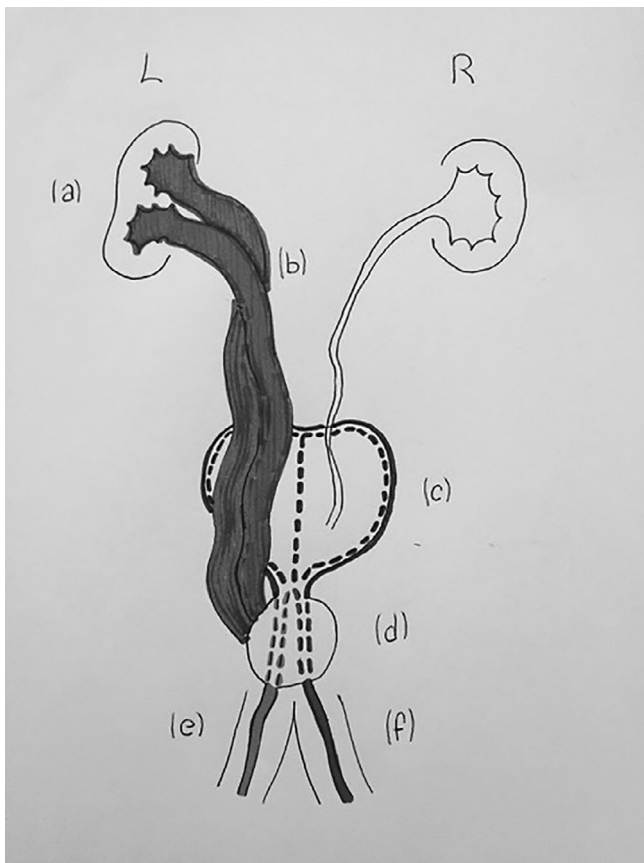


FIGURE 5 Complete left-sided duplication of the upper and lower urinary tracts. Left duplex kidney (a), left ureteral duplication and ectopia (b), left and right bladders lie side by side separated by a septum (c), prostate with left and right urethras passing into it (d), left urethra continuing into left penis (e), right urethra continuing into right penis (f)

urinary incontinence (UI), and the dog was started on a course of phenylpropanolamine (Propalin) because urethral sphincter mechanism incompetence was suspected. The owner reported persistent UI (mainly at night), and repeat CT was performed approximately 3 months postoperatively. A fluid-filled structure at the level of the terminal left two ureteric stumps and an apparent communication between these stumps and the right urethra was found by retrograde administration of positive contrast within the right penile urethra. This communication between the distal aspect of the left ureters and the right urethra had not been visible on the previous CT images. A revision surgery was therefore performed. The dog was anesthetized and prepared for surgery by using the same protocol as before. A midline surgical approach was made as previously. The abdomen was explored, and the left ureteric stumps were found firmly adhered to the colonic wall and to the lateral ligament of the bladder. A 6-Fr 55-cm Foley urethral catheter was placed intraoperatively in retrograde fashion, and retrograde filling of the bladder was performed. After temporary occlusion of the right urethral catheter, the proximal left urethra appeared patent when the bladder was manually expressed despite the suture previously placed. The left urethra was, therefore, carefully dissected free from the right urethra and ligated with two circumferential 3 M polydioxanone (PDS; Ethicon) sutures and divided immediately proximal to the prostate gland. The left ureteric stumps were dissected and amputated. The urethral catheter was removed, and the bladder was manually expressed to confirm remaining urethral patency. The abdomen was lavaged with sterile saline solution (0.9% NaCl), and the ureteric stumps were omentalized before the abdomen was routinely closed. The dog recovered from anesthesia uneventfully and was discharged the next day with oral amoxicillin-clavulanic acid (20 mg/kg every 12 hours) and oral meloxicam (0.1 mg/kg every 24 hours) for 5 days. Antibiotic treatment was administered postoperatively because preoperative infection within the ureteric stumps/left urethra could not be excluded. Postoperative healing was uneventful, with immediate and complete resolution of urinary incontinence. No recurrence of UI was reported at the final follow-up examination (>2 years postoperatively), and the preputial irritation had resolved.

4 | DISCUSSION

To the best of the authors' knowledge, this report details the first reported case of a complete unilateral duplication of the urinary tract in a dog. Surgical treatment was performed to correct the presenting clinical signs of

urinary incontinence and to reduce the risk of recurrent urinary tract infection. The dog also had symptoms of preputial irritation (pruritus) believed to be due to exposure desiccation of the right glans penis, which persistently protruded from the prepuce. These signs resolved after amputation of the left penis.

In humans with a duplex system (duplex kidney and double ureters), two ureteric buds embryologically arise separately from a single Wolffian duct. In boys with this condition, ectopic ureters can insert into the bladder, prostatic urethra, or the genital ducts.²³

The understanding of lower urinary tract duplications is, however, incomplete. Dunn and Fine²⁴ state that penile and bladder duplication could occur together if there is an incomplete fusion of the mesoderm bands, resulting in formation of two separate genital tubercles instead of one genital tubercle. The occurrence of duplication in different planes reported in one boy (coronal bladder duplication and sagittal urethral duplication), however, implies a different origin of development of lower urinary tract duplications.²⁰ The dog in the case report reported here presented with a sagittal bladder duplication extending caudally to diphallia. Prostatic duplication has not been described associated with urethral duplication in the human or the veterinary literature despite the embryology of the prostate also involving interactions between the Wolffian and Mullerian ducts and urogenital sinus (in addition to fetal testosterone). Although the prostate was assumed to be a single gland in this case because of its normal bilobed appearance, the prostate may have been incompletely duplicated with a urethra running through each section of the gland. It is also possible that, although the prostatic urethra is duplicated, the mesenchymal tissue through which it runs is not, allowing a urethral duplication through a single gland. It would be very difficult to determine which of these embryological pathways had occurred in this case.

Initial surgery involved left nephrectomy, left ureterectomies, bladder septal ablation, left phallus removal, and castration. The duplex left kidney and associated double ureters were severely dilated (hydronephrosis and hydro-ureter) and deemed end-stage, so nephroureterectomy was performed rather than any attempted correction of ureteric ectopia. The contralateral (right) kidney appeared structurally normal on preoperative imaging and during surgery, and no azotemia was noted. The structure of the bladder septum was unknown at the time of the surgery. The decision was made to ablate this septum to join both bladder compartments together because this seemed the simplest way to achieve normal anatomy, as has been described in similar cases in human medicine.²⁰ This ensured that a normal thickness of bladder wall surrounded the neobladder, maximizing the chances of normal reservoir and detrusor

function being achieved. Three case reports describe treatments of urethral duplication in dogs.¹⁰⁻¹² In one case, the dog underwent surgery to resect the supernumerary urethra.¹¹ In a second case, the dog had concomitant urethroperineal fistulae, urethrorectal fistulae and urethral duplication. The dog was taken to surgery to correct the fistulae. Eventually, the urethral duplication was not treated as the clinical signs resolved after the fistulae were removed. The authors of this case concluded that the treatment of urethral duplication is required only when clinical signs of cystitis and urine leakage develop.¹² In the third and most recent case, the urethral duplication was treated with cyanoacrylate and coil embolization.¹⁰ In all these cases, the urethral duplication presented with swelling in the penis. In our case, the presented complaint was diphallia, characterized by two urethras each of which coursed through a separate penis. Diphallia has been commonly treated by amputation of one of the penises. The decision of which penis to amputate was based on evaluation of the functionality and any malformation of each penis. In the case reported here, it was decided to ligate the duplicated urethra caudally to the bladder and amputate the left hypoplastic penis. After 3 months, however, the dog continued to be occasionally urinary incontinent, and repeat imaging revealed a fluid-filled structure dorsally and caudally to the bladder, consistent with fluid distended ureteric stumps. An extra communication between these stumps (which in turn communicated with the proximally patent left urethra) and the right (patent) urethra was visible and was thought to be contributing to ongoing clinical signs because persistence of any abnormal ureterourethral communication after the previous surgery could easily cause significant ongoing UI. Revision surgery to resect this ureteric stump and to ligate and divide the left urethra was then performed because this was noted to be patent despite previous ligation. In retrospect, it would have been better not to have left any distal ureteric tissue at their prostatic insertion and to ligate and divide the left urethra at the initial surgery. This was not performed because of uncertainty about the urethral innervation in this case and concerns about possible postoperative urethral dysfunction at the time.

Excretory urography, fluoroscopic urethrography, abdominal ultrasonography, cystoscopy, helical CT, or a combination of these procedures can be used to investigate ectopic ureters.¹⁸ Multidetector CT with intravenous contrast and retrograde urethrography were invaluable in characterizing the complex anomaly associated with the upper and lower urinary tracts of this dog. The intravenous contrast is useful for evaluating the kidneys and ureters, while the urethrography aided in defining the morphology and communication of the lower urinary tract anomalies. Because of the complexity of the malformation, removing the

superimposition of anatomy, as seen with radiographic and fluoroscopic examinations, permitted an enhanced understanding of the communications between the anomalous structures that were useful to guide surgical intervention.

In conclusion, to the best of the authors' knowledge, this is the first reported case of complete unilateral duplication of the urinary tract in a dog presenting with incontinence. Extensive embryological abnormalities should be suspected in cases of diphallia or congenital UI. Surgical resection of the duplicated system resolved the clinical signs and can provide a viable treatment option for clinicians faced with similar cases.

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AUTHOR CONTRIBUTIONS

Sprocatti M, DVM, MRCVS: Collated data, drew Figure 5, drafted the manuscript, assisted with revision of manuscript, checked final manuscript, and approved final manuscript for submission; Reese D, DVM, DACVR, MRCVS: Reviewed initial and subsequent CT used in this report, wrote imaging reports used during case management and imaging sections of this manuscript, provided CT images (and legends) for this manuscript, checked final manuscript, and approved final manuscript for submission; Charlesworth T, MA, VetMB, DSAS (Soft Tissue), MRCVS: Surgeon in charge of case, performed all reported surgery and acquired CT studies used/presented in this report, assisted with draft of manuscript and revisions, wrote responses to reviewers, checked final manuscript, and approved final manuscript for submission.

CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this report.

REFERENCES

1. O'Handley P, Carring CB, Walshaw R. Renal and ureteral duplication in a dog. *J Am Vet Med Assoc*. 1979;174(5):484-487.
2. Paradise D, Clark D. Supernumerary kidney with ipsilateral cryptorchidism in a cat. *J Am Anim Hosp Assoc*. 2013;49(5):338-341.
3. Esterline ML, Biller DS, Sicard GK. Ureteral duplication in a dog. *Vet Radiol Ultrasound*. 2005;46(6):485-489.
4. Ghantous SN, Crawford J. Double ureters with ureteral ectopia in a domestic shorthair cat. *J Am Anim Hosp Assoc*. 2006;42:462-466.
5. Novellas R, Stone J, Pratschke K, Hammod G. Duplicated ectopic ureter in a nine-year-old Labrador. *J Small Anim Pract*. 2013;54:386-389.
6. Newmann M, Landon B. Surgical Treatment of a duplicated and ectopic ureter in a dog. *J Small Anim Pract*. 2014;55:475-478.

7. Hoskins JD, Abdelbaki YZ, Root CR. Urinary bladder duplication in a dog. *J Am Vet Med Assoc*. 1982;181(6):603-604.
8. Cook AB, Langston CE, Fischetti AJ, Donovan TA. Imaging diagnosis – Urinary bladder duplication in a cat. *Vet Radiol Ultrasound*. 2015;56(4):E48-E53.
9. Johnston SD, Baile NC, Hayden DW, Johnston GR, Osborne CA. Diphallia in a mixed-breed dog with multiple anomalies. *Theriogenology*. 1989;31(6):1253-1260.
10. Palm CA, Glaiberman CB, Culp WTN. Treatment of a urethral duplication in a dog using cyanoacrylate and coil embolization. *J Vet Intern Med*. 2015;29:727-731.
11. Duffey MH, Barnhart MD, Barthez PY, Smeak DD. Incomplete urethral duplication with cyst formation in a dog. *J Am Vet Med Assoc*. 1998;213(9):1287-1289, 1279.
12. Tobias KS, Barbee D. Abnormal micturition and recurrent cystitis associated with multiple congenital anomalies of the urinary tract in a dog. *J Am Vet Med Assoc*. 1995;207(2):191-193.
13. Zucker SA, Root MV, Johnston SD. Diphallia and polymelia in a dog. *Canine Pract*. 1993;18(5):15-19.
14. Mazzullo G, Monteverde V, Macri F, Partanna S, Caracappa S. Incomplete caudal duplication in a puppy: gross and radiological observations. *J Small Anim Pract*. 2007;48:410-413.
15. Laube R, Cook A, Winkler K. Diphallia in a mixed-breed puppy: case report. *J Am Anim Hosp Assoc*. 2017;53:281-284.
16. Axné E, Strom B, Linde-Forsberg C, Gustavsson I, Lindblad K, Wallgren M. Reproductive disorders in 10 domestic male cats. *J Small Anim Pract*. 1996;37(8):394-401.
17. Privett JTJ, Jeans WD, Roylance J. The incidence and importance of renal duplication. *Clin Radiol*. 1976;27:521-530.
18. Whitten SM, Wilcox DT. Duplex systems. *Prenat Diagn*. 2001;21(11):952-957.
19. Lisieux EJ, Dekermacher S, Lopes E, Bacon AP. Glans duplication: in-depth review and proposal of a new classification. *J Pediatr Urol*. 2017;13:172-176.
20. Woodhouse CR, Williams DI. Duplications of the Lower Urinary Tract in Children. *Br J Urol*. 1979;51:481-487.
21. Hoelzler MG, Lidbetter DA. Surgical management of urinary incontinence. *Vet Clin Small Anim Pract*. 2004;34:1057-1073.
22. Boothe HW. Penis and prepuce. In: Johnston SA, Tobias KM, eds. *Veterinary Surgery: Small Animal*. Vol 2. St Louis, MO: Elsevier/Saunders; 2018.
23. Didier RA, Chow JS, Kwatra NS, Retik AB, Lebowitz RL. The duplicated collecting system of the urinary tract: embryology, imaging appearances and clinical considerations. *Pediatr Radiol*. 2017;47:1526-1538.
24. Dunn D, Fine RG. Diphallia, double bladder, and two hemiscrotums: a case report. *AORN J*. 2019;109(6):728-740.

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