Received: 29 July 2016 | Accepted: 5 January 2017

DOI 10.1111/vsu.12654

ORIGINAL ARTICLE

Surgical management of ectopic ureters in dogs: Clinical outcome and prognostic factors for long-term continence*

Stéphanie M. Noël, DVM, PhD, Diplomate ECVS |
Stéphanie Claeys, DVM, PhD, Diplomate ECVS |
Annick J. Hamaide, DVM, PhD, Diplomate ECVS

Department of Clinical Sciences, College of Veterinary Medicine, Liège, Belgium

Correspondence
Annick J. Hamaide, Department of Clinical Sciences, College of Veterinary Medicine, Liège, Belgium.
Email: Annick.Hamaide@ulg.ac.be

Abstract

Objective: To determine outcomes after surgical correction of ectopic ureters (EU) and identify prognostic factors for long-term continence.

Study design: Retrospective study.

Animals: Forty-seven dogs (36 females and 11 males).

Methods: Medical records (1999-2016) of dogs with surgical correction of EU were reviewed. A continence score (1 = incontinent, 2 = sporadic incontinence, 3 = continent) was attributed preoperatively, at discharge, 1 month postoperatively, and at long-term evaluation.

Results: Twenty-eight dogs had unilateral and 19 dogs had bilateral EU (57 intramural and 9 extramural). Nineteen dogs had a pelvic bladder. Neoureterostomy with dissection (n = 50), ureteroneocystotomy (n = 9), or nephroureterectomy (n = 7) were performed. Thirty-three dogs were neutered: 32 before or during the surgery and 1 after surgery. Colposuspension was performed during surgical correction in 15 dogs. Adjuvant medical treatment improved postoperative continence scores. Median continence scores were greater at discharge (3), at 1 month postoperatively (3), and at long-term evaluation (3) than before surgery (1). At long-term evaluation (mean 46.1 months), a score of 1 was observed in 19%, a score of 2 in 7%, and a score of 3 in 74% of the dogs.

Conclusion: Overall, good (score 2) to excellent (score 3) long-term outcome was achieved in 81% of dogs. Long-term continence was improved with medical treatment and neutering was not associated with an increased risk of recurrence of incontinence in this population of dogs.

1 | INTRODUCTION

Long-term incontinence after surgical correction of ectopic ureters (EU) is a debilitating postoperative complication that is more common in female dogs. Reported postoperative continence rate after surgical correction of EU without adjunct treatment ranges from 22% to 72%.[1-9] In male dogs, a continence rate of 82% has been reported.[10] Cystoscopic-guided laser ablation provides a similar outcome in female dogs, with a continence rate of 25%[11] and 47%.[12] In male dogs, the continence rate was 100%[13] but only 4 dogs were included in the study. Postoperative adjunct medical treatment, mostly phenylpropanolamine (PPA) or estrogens, generally improves continence rates.[4,5,7,8,11,12,14]

The persistence or recurrence of urinary incontinence after correction of EU have been attributed to several factors,

*Part of the study was presented at the BSAVA Congress, April 4, 2014, Birmingham.

such as lower urinary tract infection (UTI), recanalization of the ligated ureter, disturbed urethral closure due to residual intramural EU, congenital urethral sphincter mechanism incompetence (USMI), poorly developed trigone, hypoplastic bladder, vestibulovaginal stenosis, neurogenic abnormalities, hormonal imbalance, or inadequate surgery.[4-6,14-16] Several studies have focused on prognostic factors for postoperative continence. The type, side, number of EU, as well as the presence of preoperative hydroureter and UTI did not influence postoperative continence in affected dogs.[4,14] In another study, the postoperative continence rate in case of intramural EU was not influenced by the surgical technique selected, whether the EU was treated via ligation of the distal ureteral segment or resection of the distal segment.[7] Recently, a modified neoureterostomy, where the distal ureter was left in situ without ligating the distal segment, resulted in continence in 6 of 9 female dogs.[9]

Urodynamic investigation, including urethral pressure profile (UPP) and cystometry, has been proposed to assess the vesico-urethral function in dogs with EU. Lane et al. (1995) showed that 67% of dogs with EU had urodynamic characteristics of USMI and 44% of those dogs had a small bladder capacity. In another study, a low urethral pressure was recorded in 4 out of 4 dogs with EU.[17] The results prompted authors to propose that concurrent USMI is present in dogs with EU, and that urodynamics could help in predicting postoperative outcome. Congenital USMI is the second cause, after EU, of urinary incontinence in juvenile animals,[18] and approximatively half of affected juvenile dogs become continent following the first[18-20] or second estrus.[20] Persistent paramesonephric remnant has been recently reported in juvenile female dogs with urinary incontinence[21,22] and, especially, in soft-coated Wheaten Terriers.[22] EU and persistent paramesonephric remnant are often combined.[21,22] Acquired USMI is the most common cause of urinary incontinence in adult spayed bitches.[18,19] Predisposing factors for USMI include decreased urethral resistance,[23-25] pelvic bladder with or without a short urethra,[26-28] and neutering.[18,29,30] Limited evidence is available regarding simultaneous colposuspension and surgical correction of EU, in dogs with concurrent pelvic bladder and EU. In one study, 2 out of 2 female dogs remained incontinent after these procedures,[14] whereas 5 out of 5 females remained continent at long-term follow-up in another report.[31] Lastly, Reichler et al[8] speculated that the high long-term continence rate (72%) reported in their study could reflect the relatively low representation of spayed bitches. Studies evaluating the impact of colposuspension and neutering on urinary continence after surgical correction of EU are lacking. Such knowledge would provide evidence to guide recommendations for dogs with EU and potentially improve their postoperative continence rates.

The objectives of the present retrospective study were to report the clinical outcome after surgical correction of EU in dogs, and to identify prognostic factors for long-term continence. The influence of colposuspension and neutering on long-term continence was also evaluated. The first hypothesis was that colposuspension performed during the surgical correction of EU improves the postoperative urinary continence. The second hypothesis was that neutering does not influence the postoperative urinary continence.

2 | MATERIALS AND METHODS

2.1 | Inclusion criteria

Medical records of dogs that underwent surgical correction of EU between 1999 and 2016 were reviewed. Data included gender, neuter status, diagnostic imaging findings, surgical findings, type of surgery, postoperative complications at short- and long-term follow-up, and additional postoperative medical treatment. Breeds were recorded and grouped as large, medium, and small breeds. Follow-up information was obtained by patient evaluation and long-term outcome was determined based on telephone interviews of owners or referring veterinarians.

2.2 | Diagnostic procedures

A complete blood analysis (hematology and biochemistry), urinalysis (urine dipstick and urine cytology), and urine culture were obtained before diagnostic imaging procedures. In some dogs, UPP and cystometry, as well as endoscopy, were also performed.

Diagnostic imaging procedures included abdominal ultrasonography, intravenous pyelogram combined with pneumocystography, retrograde urethrography, or retrograde vaginourethrography combined with cystography. A pelvic bladder was diagnosed when at least 5% of the bladder's length was located within the pelvis.[32]

2.3 | Surgical procedures

Extramural EU were treated via ureteroneocystotomy. The distal end of the EU was ligated, transected, and a stay suture was placed at the free end of the ureter. After ventral cystotomy, a stab incision was made in the trigone area and a small pair of hemostats was pushed through the bladder wall to grasp the stay suture. The damaged portion of the distal ureter was excised and spatulated to the new opening. Simple interrupted sutures using 5-0 synthetic absorbable suture material were placed between the ureteral and bladder wall. The cystotomy and the abdominal wall were closed routinely.

Intramural EU were treated via neoureterostomy and dissection of the intramural portion of the EU. A stay suture was placed at the apex of the bladder to allow cranial retraction and exposure of the cranial pelvic urethra. After a ventral cystotomy and urethrotomy, the distal opening of the ureters was catheterized. If the distal opening of the EU was located too far caudally to allow exposure, a stab incision was performed as far as possible into the EU, which was then catheterized. The distal part of the EU was ligated. The ectopic part of the ureter, between the ligature and the trigone area, was dissected and excised. The ureter was spatulated and sutured to the bladder wall with simple interrupted sutures of 5-0 synthetic absorbable suture material. The urethral defect created by the dissection of the intramural portion of EU was closed in a simple continuous pattern with 5-0 synthetic absorbable suture material. The cystotomy and the abdominal wall were closed routinely.

A nephroureterectomy was performed in dogs with severe kidney malformation diagnosed by imaging procedures and characterized by a loss of normal kidney architecture (hypoplasia, hydronephrosis). In some of those dogs, the intramural portion of the EU was dissected and excised.

In selected dogs and depending on surgeon's preference, colposuspension was performed as previously described.[33] Briefly, sutures of 2-0 monofilament polypropylene were placed through the abdominal wall caudal to the prepubic tendon, penetrating into the vaginal wall, prior to exiting the abdominal wall cranial to the prepubic tendon. Two sutures were placed around each prepubic tendon. Ovariectomy or orchidectomy (castration) was performed concurrently after owner agreement. All surgical procedures were performed by a board certified surgeon.

2.4 | Postoperative management

A Foley urinary catheter was placed for 24-48 hours in each dog. Urinary incontinence, hematuria, stranguria, dysuria, and signs of abdominal discomfort were recorded after removal of the urinary catheter. Diagnostic procedures were repeated if clinical signs of complication occurred and surgical revision was performed if needed.

Analgesia was provided by different protocols, relying on a combination of opioids and nonsteroidal anti-inflammatory drugs, based on clinician's preference. Prolonged postoperative antibiotherapy was administered in the presence of preoperative UTI.

2.5 | Follow-up evaluation

Complete physical examination, abdominal ultrasonography, and an intravenous pyelogram combined with pneumocystography were recommended 1 month after surgery, to evaluate the morphology of kidneys and ureters, as well as the site of uretero-vesical anastomosis. A retrograde vaginourethrography was also performed in some dogs. In cases with UTI at the time of surgery, urinalysis and urine culture were repeated. No further recheck was proposed if the dog was fully continent. Additional rechecks were scheduled in dogs with persistent or recurrent incontinence. In addition to the diagnostic imaging procedures, UPP and cystometry were performed to evaluate vesico-urethral function. Additional medical or surgical treatment was then proposed. Long-term evaluation was based on telephone interviews with owners or referring veterinarians.

2.6 | Data analysis

A continence score was assigned as follows: 1 = incontinent, 2 = continent with sporadic episodes of incontinence, 3 = fully continent. This score was attributed at 4 time points: preoperatively, at discharge, at 1 month postoperatively, and at long-term evaluation. A good outcome was defined as dogs with a continence score of 2 and an excellent outcome was defined for dogs with a continence score of 3.

Descriptive data are presented as units, percentages, mean ± SD (range), and median. Normality of data was not assessed because the scores followed a multinomial distribution. The absence of normality was confirmed by the Shapiro-Wilk test. Statistical analyses were performed using the GLIMMIX procedure of the SAS software (SAS/STAT software, SAS Institute Inc., Cary, North Carolina) to determine the influence of the different factors (breed, gender, neuter status, age at the time of surgery, unilateral or bilateral EU, pelvic bladder, congenital urogenital abnormalities), type of surgery (ureteroneocystotomy, neoureterostomy, nephroureterectomy), neutering, colposuspension during the surgical correction of EU) on the postoperative continence scores. The continence scores were analyzed by multinomial regression model, in which were set as cofactors: gender, race group, the position of the bladder, neutering, colposuspension, and the time of neutering. The 4 time points at which the scores were collected on each dog were analyzed in terms of a logical correlation between successive scores for each animal. Univariate analysis models were first tested for each factor independently of the other, in order to evaluate which variable was likely to have an impact on the continence score and then in order to gather the relevant factors in a multivariate model. A P value $< .05$ was considered significant.

3 | RESULTS

Forty-seven dogs underwent surgical correction of EU (Table 1), including 36 female and 11 male dogs, with a mean age

TABLE 1 Demographics and urinary continence of dogs with ectopic ureters

Dog	Sex	Type of EU	Type of surgery	Periop. Neuter	ColpoS.	Continence score			
						Preop. time	Discharge	1 mth PO	Long term
1	M	Extra	Ureteroneocystotomy	Yes	No	1	1	2	3
2	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	Yes	1	3	3	2
3	M	Intra	Neoureterostomy	No	No	1	3	3	. . .
4	M	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	3	. . .
5	F	Intra	Neoureterostomy	No	Yes	1	3	3	3
6	F	Intra	Neoureterostomy	No	Yes	1	3	3	3
7	F	Intra/extra	Neoureterostomy/ ureteroneocystotomy	No	No	1	3	3	. . .
8	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	Yes	1	3	1	1
9	M	Extra/extra	Ureteroneocystotomy/ ureteroneocystotomy	Yes	No	1	3	3	3
10	F	Intra/intra	Neoureterostomy/ neoureterostomy	No	Yes	1	3	. . .	3
11	F	Intra/extra	Neoureterostomy/ ureteroneocystotomy	No	No	1	1	3	2
12	F	Intra	Neoureterostomy	Yes	Yes	1	3	3	1
13	F	Intra	Neoureterostomy	Yes	Yes	1	3	3	3
14	F	Intra	Neoureterostomy	Yes	Yes	1	3	3	3
15	F	Intra	Neoureterostomy	Yes	No	1	1	1	1
16	F	Intra	Nephroureterectomy	Yes	No	1	3	. . .	. . .
17	M	Intra	Nephroureterectomy	No	No	1	3	. . .	3
18	F	Intra	Neoureterostomy	Yes	No	1	3	3	3
19	M	Intra	Nephroureterectomy	Yes	No	1	3	3	3
20	F	Intra	Nephroureterectomy	Yes (after the Sx)	No	1	3	2	1
21	F	Intra/intra	Neoureterostomy/ nephroureterectomy	No	No	1	3	3	3
22	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	. . .	3
23	F	Intra	Neoureterostomy	No	No	1	3	3	3
24	F	Intra/intra	Neoureterostomy/ neoureterostomy	No	No	1	3	3	1
25	F	Intra	Neoureterostomy	Yes	No	1	3	3	3
26	F	Intra	Neoureterostomy	Yes	No	1	3	3	3

(*continues*)

TABLE 1 (continued)

Dog	Sex	Type of EU	Type of surgery	Periop. Neuter	ColpoS.	Continence score			
						Preop. time	Discharge	1 mth PO	Long term
27	F	Intra	Neoureterostomy	Yes	No	1	3	3	1
28	M	Intra	Neoureterostomy	Yes	No	1	3	3	3
29	F	Intra	Neoureterostomy	Yes	No	1	3	. . .	1
30	M	Intra	Nephroureterectomy	No	No	1	3	3	3
31	F	Intra	Neoureterostomy	No	No	1	3	3	3
32	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	3	3
33	F	Intra	Nephroureterectomy	Yes	Yes	1	1	1	1
34	M	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	3	3
35	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	Yes	1	3	3	2
36	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	Yes	1	3	3	3
37	M	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	3	3
38	F	Intra	Neoureterostomy	Yes	No	1	3	3	3
39	F	Intra	Neoureterostomy	No	No	1	3	. . .	3
40	F	Extra/extra	Ureteroneocystotomy/ ureteroneocystotomy	Yes	No	1	3	3	3
41	F	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	3	3
42	F	Intra	Neoureterostomy	Yes	Yes	1	3	3	3
43	F	Intra	Neoureterostomy	Yes	Yes	1	3	3	3
44	F	Intra	Neoureterostomy	Yes	Yes	1	3	3	3
45	F	Extra/extra	Ureteroneocystotomy/ ureteroneocystotomy	Yes	No	1	3	. . .	3
46	M	Intra/intra	Neoureterostomy/ neoureterostomy	Yes	No	1	3	3	3
47	F	Intra	Neoureterostomy	No	Yes	1	3	3	3

Abbreviations: ColpoS, colposuspension; EU, ectopic ureter; extra, extramural; intra, intramural; PO, postoperative; continence score; 1 = incontinent; 2 = sporadic incontinence; 3 = continent.

of 14 months (range, 2-91 months). All dogs had a history of continuous dribbling of urine since birth or weaning. Most common breeds included Golden Retrievers (10), Labrador Retrievers (7), and Beaucerons (6). Twenty-seven dogs were included in the large breed dog group, 10 in the medium breed dog group, and 10 in the small breed dog group.

Twenty-eight dogs (60% of the dogs) had unilateral and 19 (40% of the dogs) had bilateral EU, including 57 intramural (86% of the EU) and 9 extramural EU (14% of the EU). Congenital anomalies were detected in 34 dogs (72%) during the preoperative assessment, including hydroureters (18; 27% of the ureters), hydronephrosis (16; 24% of the

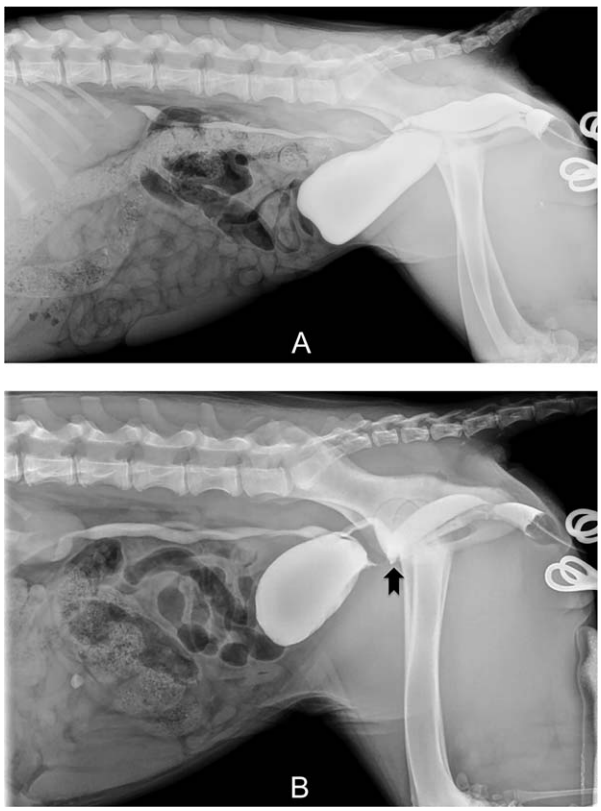

FIGURE 1 A, Preoperative vaginourethrography in a female dog with bilateral ectopic ureters and pelvic bladder. B, Postoperative vaginourethrography of the dog, after neoureterostomy with dissection of the intramural portion and concurrent colposuspension (black arrow)

kidneys), renal hypoplasia (6; 6% of the kidneys), ureterocele (3; 5% of the ureters), and hypospadias (1; 2% of the dogs). A pelvic bladder was diagnosed in 19 dogs (40%) (Figure 1A). Colposuspension was performed at the time of surgical correction of EU in 16 dogs (34%), 15 of those with a pelvic bladder (Figure 1B). Depending on the type of EU, neoureterostomy with dissection of the intramural portion (50 EU; 76% of EU), ureteroneocystostomy (9 EU; 14% of EU), or nephroureterectomy (7 EU; 11% of EU) were performed. Ovariectomy (24 female dogs) or castration (8 male dogs) was performed in 32 dogs (68% of the dogs) before or during surgical correction. The mean and median age at the time of neutering was 14.7 and 9 months, respectively.

Minor postoperative complications occurred in 15 dogs (32%) and included dysuria (7; 47% of minor complications), pollakiuria (5; 33%), and hematuria (3; 20%). One of those dogs received diazepam orally (5 mg 3 times a day) to treat slight dysuria and pollakiuria after colposuspension.

Major complications, defined as requiring surgical revision, occurred in 5 dogs (11%) and included uroabdomen (3) and severe dysuria due to the colposuspension (2). Uroabdomen was secondary to leakage at the anastomotic site in 1 dog, to dehiscence of the cystotomy incision in 1 dog, and to leakage at the apex of the bladder (through the stay suture site) in 1 dog. Surgical revision and thorough abdominal lavage led to recovery in those 3 dogs. Severe dysuria was treated by removal of all 4 sutures of the colposuspension in 1 dog and by removal of 2 sutures in 1 dog.

Data regarding the presence of bacterial cystitis were available preoperatively in 32 dogs (68% of the dogs), at the time of surgery in 9 dogs (19% of dogs), 1 month postoperatively in 23 dogs (58% of the dogs), and at long-term follow-up in 34 dogs (79% of the dogs). Positive urine cultures were present in 16, 2, and 10 dogs, preoperatively, at the time of surgery, and 1 month later, respectively. At long-term follow-up, owners reported the absence of cystitis in 18 dogs, frequent episodes of cystitis in 4 dogs, and rare episodes of cystitis in 12 dogs.

Diagnostic imaging was proposed in all dogs 1 month after surgery. Abdominal ultrasonography was performed in 28 dogs, all with intramural EU except 1 dog. Twenty-six of these dogs achieved a continence score of 3, including 10 dogs treated with a colposuspension. One dog received a continence score of 2 and had no colposuspension, and 1 dog with colposuspension had a continence score of 1. The ureteral jets were observed within the bladder in all dogs, findings were within normal limits in 9 dogs, hydronephrosis was improved in 7 dogs, and hydronephrosis associated with hydroureters was stable in 12 dogs. Intravenous pyelogram combined with pneumocystography was performed in 6 additional dogs, combined with a retrograde vaginourethrography in 2 of these dogs, and combined with a retrograde urethrography in 1 other dog. All these dogs, except 1, had intramural EU. Five out of these 6 dogs were continent, of which 2 had a colposuspension. Examination was within normal limits in all dogs with visualization of the ureteral jets within the bladder. Retrograde vaginourethrography was performed in 13 dogs and was within normal limits in all dogs. Nine out of these 13 dogs had a colposuspension and had a continence score of 3, and 1 dog had a colposuspension and a continence score of 1. One dog had a continence score of 3, and 2 dogs had a continence score of 2 without colposuspension. Retrograde uretrography was performed in 1 male dog with bilateral extramural EU and was within normal limits.

Breed, gender, unilateral versus bilateral EU, extramural versus intramural EU, the presence of congenital urogenital anomalies (hydroureter, hydronephrosis, renal hypoplasia, ureterocele, hypospadias), the presence of a pelvic bladder, age at surgery, type of surgery, neutering, and colposuspension during the surgical correction of EU were not found to have a prognostic value on postoperative continence scores. Administration of a medical treatment at 1 month postoperatively and at the long-term evaluation was a positive prognostic factor for urinary continence ($P = .0141$ and $P = .007$, respectively).

TABLE 2 Preoperative and postoperative continence scores

Continence score	Preoperative time (n = 47)	Discharge (n = 47)	One month follow-up (n = 40)	Long-term follow-up (n = 43)
1	47 (100%)	4 (9%)	3 (7.5%)	8 (19%)
2	0	0	2 (5%)	3 (7%)
3	0	43 (91%)	35 (87.5%)	32 (74%)
Median score	1[a]	3[b]	3[b]	3[b]
Mean score ± SD	1 ± 0[a]	2.8 ± 0.56[b]	2.8 ± 0[b]	2.6 ± 0.76[b]

Continence score: 1 = incontinent, 2 = sporadic incontinence, 3 = continent.
For the mean and the median continence scores, the values with different superscripts are significantly different ($P < .05$).

Long-term follow-up was available in 43 animals, with a mean duration of 46.1 months (range, 4-148 months, median 32 months). The overall median continence score of the dogs, including dogs with postoperative adjuvant medical treatment, was higher at discharge (3; $P < .0001$, Table 2), at 1 month postoperatively (3; $P < .0001$), and at long-term evaluation (3; $P < .0001$) compared to the preoperative scores (1). No differences were detected between the postoperative continence scores.

Incontinence recurred in 15 dogs (32% of the dogs; 13 spayed female dogs, 1 entire female dog, 1 neutered male dog) after a mean period of 4.7 months (range, 1-12 months). Six of the 13 spayed female dogs with postoperative incontinence had a colposuspension. All the female dogs (14 dogs) had urinary leakage in recumbent position or during increased activity. The male dog had nocturia, as well as urinary leakage in recumbent position, and during activity. A small bladder capacity was measured via cystometry and successfully treated with oxybutynin (3.75 mg orally twice daily; Oxybutynin EG, Eurogenerics, Brussels, Belgium) administered for a limited time. All male dogs were fully continent at long-term follow-up. In case of recurrence of urinary incontinence, urodynamic examination was proposed. UPP was performed in 7 dogs and cystometry was performed in 4 dogs. A low maximal urethral pressure compatible with USMI was measured in 6 dogs and bladder instability (high bladder pressure and low bladder capacity) was diagnosed in 1 dog. Three dogs with USMI had low bladder capacity.

Seventeen female dogs received adjuvant medical treatment at different time points of the follow-up (Table 3). Five dogs were discharged with medication: 4 received PPA (1.5 mg/kg orally once daily; Propalin, Vetoquinol, Aartselaar, Belgium) and 1 received diazepam (5 mg orally 3 times a day; Valium, Roche, Brussels, Belgium). At 1 month postoperatively, 3 dogs were receiving PPA (1.5 mg/kg orally once daily) and 1 dog was receiving diazepam (5 mg orally 3 times a day) and oxybutynin (3.75 mg orally twice

TABLE 3 Dogs with postoperative adjunct medical treatment

Dog	Medical treatment		
	Discharge	One month postoperatively	Long term
1	PPA SID	PPA SID	No
2	No	No	PPA BID + Estriol SID: discontinous administration
8	No	No	PPA BID + Estriol SID
11	PPA SID	No	PPA SID: discontinous administration
14	Diazepam TID	No	No
15	PPA SID	PPA SID	No
18	No	No	PPA BID + Estriol SID
20	No	No	PPA SID
24	No	No	PPA SID
26	No	No	PPA SID
27	No	No	PPA SID
33	PPA SID	PPA SID	PPA SID
35	No	Diazepam TID + Oxybutynin BID	No
36	No	No	PPA SID
40	No	No	PPA SID
42	No	No	PPA SID
44	No	No	PPA SID

Abbreviations: BID, twice a day; PPA, phenylpropanolamine; SID, once a day; TID, three times a day. Phenylpropanolamine, 1.5 mg/kg PO; Estriol, 1 mg/dog PO; Diazepam, 5 mg/dog PO; Oxybutynin, 3.75 mg/dog PO.

daily). At the long-term evaluation, 9 dogs were receiving PPA daily (1.5 mg/kg orally once daily), and 1 dog was receiving PPA (1.5 mg/kg orally once daily) only during the episodes of sporadic incontinence. Two dogs were receiving PPA (1.5 mg/kg orally twice daily) and estriol (1 mg orally once daily; Incurin, Intervet, Brussels, Belgium) daily, and 1 dog was receiving both drugs only during the episodes of sporadic incontinence.

4 | DISCUSSION

The demographics of our population are consistent with previous reports of ureteral ectopia.[2,16,19,34-36] Female dogs and intramural EU were overrepresented in our population, with urinary leakage reported since birth in all cases. Other congenital urogenital anomalies were present in approximately two-thirds of the animals. Retriever dogs (Labrador and Golden) were overrepresented and some of these dogs were littermates. Beaucerons represented 13% of our population of dogs. A genetic basis for EU is suspected and the heritability of this condition was recently confirmed in the Entlebucher Mountain dog.[37,38] In agreement with a previous study,[14] breed, gender, unilateral versus bilateral EU, extramural versus intramural EU, as well as the presence of congenital urogenital anomalies were not found to be prognostic factors influencing postoperative continence.

In this study, a good to excellent outcome was achieved in 92.5% of dogs 1 month postoperatively and in 81% of dogs at long-term outcome. A true recurrence of incontinence was observed in 35% of the dogs during the follow-up, most of these responding to adjuvant medical treatment. This complication has been attributed to different causes depending on the surgical correction selected. The first type of neoureterostomy described to treat intramural EU involves ligation of the distal ureteral segment. Recanalization of the distal segment can result in recurrence of urinary incontinence. The reflux of urine in the distal segment leads to urinary stasis and UTI, which may interfere with the urethral sphincter mechanism.[2,3] In addition, the presence of an EU within the urethral wall has been proposed to alter interactions between factors that contribute to the maintenance of urethral pressure, thereby compromising urinary continence.[39-41] The second type of neoureterostomy requires resection of the distal ureteral segment, along with reconstruction of the urethra and trigone. This technique decreases the risks of recanalization and urinary stasis at the level of the distal segment. The anatomy of the urethra is restored but this procedure is more challenging and may lead to iatrogenic urethral damage and hemorrhage.[16] A previous comparison of the 2 types of neoureterostomies found no difference in long-term urinary continence.[7] Urinary continence was reached in 29% of dogs in the ureteral resection group and in 50% of dogs in the ligation group, with a surgical outcome judged as excellent by the owners of 10 of 18 (56%) dogs in the resection group and 9 of 14 (64%) dogs in the ligation group.[7] However, a higher improvement rate was observed after medical treatment in the resection group, which could result from the restoration of the urethral sphincter mechanism. In the present retrospective study, dogs with urinary incontinence after resection of the intramural ureteral segment responded well to medical treatment, consisting mainly of α-adrenergic agents.

This retrospective study did not detect an association between colposuspension at the time of surgical correction of EU in dogs with pelvic bladder and postoperative urinary continence. The effect of colposuspension combined with surgical correction of EU on the continence score should be analyzed in a prospective study and on a larger population. Similarly, the presence of a pelvic bladder did not affect the postoperative continence scores. However, these results must be interpreted with caution as very few dogs with pelvic bladder were not treated with colposuspension at the time of EU correction. Pelvic bladder has been proposed as a causative factor for urinary incontinence,[18,26] based on an unbalanced distribution of abdominal pressure between the bladder and urethra, when the neck of the bladder is intrapelvic.[2,20] However, one study reported that decreased pressure transmission on the urethra did not contribute to the pathophysiology of urinary incontinence due to urethral incompetence in bitches.[42] The colposuspension is designed to position the bladder neck in an intraabdominal position,[33] increase anatomical and functional urethral length,[33,43] and to improve transmission of abdominal pressure from the bladder to the urethra.[44] Long-term outcome after colposuspension in dogs with USMI is fair, resulting in urinary continence in 14%-53% of the dogs, and improving the function of 33%-42% cases.[33,43,45] Concurrent surgical treatment of EU and colposuspension in 9 dogs with pelvic bladder has recently been reported to result in continence in all dogs at 60 days after the surgery. A telephone follow-up was available in 5 of these dogs 15-21 months after surgery, confirming persistence of urinary continence in all dogs.[31]

The relative distribution of gender in studies of dogs with EU has been proposed to influence surgical outcomes. Reichler et al[8] suggested that the low representation of spayed dogs in their study may explain their high postoperative continence rate after EU correction. Indeed, spay seems linked to USMI, as 90% of bitches with USMI are spayed,[18,27] and up to 20% of spayed bitches can develop urinary incontinence.[30] Spaying is associated with vesicourethral structural modifications, such as a decrease in smooth muscle and an increase in the volume of vascular urethral plexus.[46,47] The influence of structural modifications in collagen content remains controversial,[46,48] with recent

studies documenting an increased proportion of collagen in both bladder and urethra from neutered dogs.[47] Excessive collagen deposit and decreased muscle volume could impair the functional integrity of the lower urinary tract. Spaying can also modify urethral function, decreasing maximal urethral pressure,[49-51] functional urethral length, and integrated pressure.[52] Despite the structural and functional effects of spaying, preoperative or concurrent neutering was not identified as a negative prognostic factor for urinary incontinence at long-term follow-up in our study. These findings must be interpreted with caution as colposuspension was performed in some of those spayed dogs at the time of surgical correction. Although 91% of dogs were continent at discharge, incontinence recurred in nearly 35% of animals, a rate higher than that in spayed female dogs (4.5%[53]-20%[30]). This finding prompts us to suggest that neutering-induced USMI is unlikely to be the only factor involved in recurrence of incontinence. However, further prospective studies on a larger number of dogs are needed to better define the impact of neutering on dogs with EU.

Recurrence of urinary incontinence after surgical correction of EU is rarely reported in the literature[6,10,31] and justifies long-term evaluation, such as provided in our study, with a mean follow-up time of 46.1 months. Clinical signs in dogs with recurrent incontinence differed from those observed preoperatively, consisting of urine leakage during recumbency or during increased activity rather than continuous dribbling of urine. Recanalization of the distal ureteral remnant, extending beyond the dissected portion, was not diagnosed in any of the dogs with postoperative incontinence. Although uncertain, USMI is the most likely cause for recurrence of urinary incontinence in these dogs. While the resection technique could improve the response to postoperative medical treatment, this advantage must be weighed against the potential disruption of the urethral mechanism during dissection of the distal ureteral segment, potentially leading to postoperative USMI. However, based on the good short-term continence rate reported in the present study, disruption of the urethral mechanism does not appear to be a likely negative factor for postoperative incontinence. Urinary incontinence occurred at a mean of 5 months after surgery, and a majority of dogs remained continent postoperatively. A simple neoureterostomy technique was recently described, in which no resection or ligation of the distal segment was performed. A continence rate of 66% was obtained but only 9 dogs were included.[9] Reichler et al[8] described a similar postoperative continence rate at long-term evaluation (72%) although the neoureterostomy in their report was modified by limiting the resection to the intravesicular ureteral segment in order to preserve the urethral sphincter. Minimally invasive correction of intramural EU by cystoscopic-guided laser ablation does not seem to improve postoperative outcome, leading to continence in 25%-47% in female dogs.[11,12] Prospective studies with histological and urodynamic examinations are needed to determine the impact of distal ureteral segments on long-term continence and whether their dissection influences the urethral sphincter mechanism.

Urinary incontinence in dogs with EU may also result from concurrent congenital USMI, a condition difficult to diagnose. The diagnostic accuracy of UPP to detect USMI remains unclear and warrants further research. However, serial UPPs performed before and after surgery may be consistent with congenital USMI if urethral pressure does not increase postoperatively. Age at the time of surgery should also be considered in dogs suspected of USMI. The mechanism responsible for urinary continence has been found to develop during the prepubertal period in female Beagle dogs and improve during the first 2 estrous cycles.[54] As surgical correction of EU is usually performed in very young animals, concurrent neutering in those dogs may precede complete development of their urinary continence mechanism. Finally, USMI could be due to an abnormal composition of the trigone and urethral wall as EU results from dysembryogenis of the ureteral bud related to its abnormal positioning along the mesonephrotic duct.[55-57] Histological and prospective studies are needed to investigate the causative role of these mechanisms.

Major limitations of this study relate to its retrospective nature, including missing information, absence of a control group, and loss of cases at follow-up. In addition, long-term follow up was limited to telephone call rather than physical examination. Finallly, our inability to detect an association between candidate prognostic factors and postoperative outcome may be due to the small size of our population.

In conclusion, a good to excellent long-term overall continence rate of 81% can be reached after successful correction of EU. Long-term continence can be improved by adjunct medical treatment. The lack of association between neutering and postoperative incontinence should be interpreted with caution due to the small number of cases in our study and warrants further prospective investigation in a larger population.

CONFLICT OF INTEREST

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

REFERENCES

[1] Dean PW, Constantinou CE. Canine ectopic ureter. *Comp Contin Educ Pract Vet.* 1988;10:147-157.

[2] Holt PE, Gibbs C. Canine ectopic ureter—a review of twenty-nine cases. *J Small Anim Pract.* 1982;23:195-208.

[3] Stone EA, Mason LK. Surgery of ectopic ureters: types method of correction, and postoperative results. *J Am Anim Hosp Assoc.* 1990;26:81-88.

[4] McLaughlin R, Miller CW. Urinary incontinence after surgical repair of ureteral ectopia in dogs. *Vet Surg.* 1991;20:100-103.

[5] Lane IF, Lappin MR, Seim HB III. Evaluation of results of preoperative urodynamic measurements in nine dogs with ectopic ureters. *J Am Vet Med Assoc.* 1995;206:1348-1357.

[6] Holt PE, Moore AH. Canine ureteral ectopia: an analysis of 175 cases and comparison of surgical treatments. *Vet Rec.* 1995;136: 345-349.

[7] Mayhew PD, Lee KC, Gregory SP, et al. Comparison of two surgical techniques for management of intramural ureteral ectopia in dogs: 36 cases (1994-2004). *J Am Vet Med Assoc.* 2006; 229:389-393.

[8] Reichler IM, Eckrich Specker C, Hubler M, et al. Ectopic ureters in dogs: clinical features, surgical techniques and outcome. *Vet Surg.* 2012;41:515-522.

[9] Volstad NJ, Beck J, Burgess DM. Correction of intramural ureteral ectopia by ureteral transection and neoureterostomy with the distal ureter left in situ. *Aust Vet J.* 2014;92:81-84.

[10] Anders KJ, McLoughlin MA, Samii VF, et al. Ectopic ureters in male dogs: review of 16 clinical cases (1999-2007). *J Am Anim Hosp Assoc.* 2012;48:390-398.

[11] Smith AL, Radlinsky MG, Rawlings CA. Cystoscopic diagnosis and treatment of ectopic ureters in female dogs: 16 cases (2005-2008). *J Am Vet Med Assoc.* 2010;237:191-195.

[12] Berent AC, Weisse C, Mayhew PD, et al. Evaluation of cystoscopic-guided laser ablation of intramural ectopic ureters in female dogs. *J Am Vet Med Assoc.* 2012;240:716-725.

[13] Berent AC, Mayhew PD, Porat-Mosenco Y. Use of cystoscopic-guided laser ablation for treatment of intramural ureteral ectopia in male dogs: four cases (2006-2007). *J Am Vet Med Assoc.* 2008;232:1026-1034.

[14] Ho LK, Troy GC, Waldron DR. Clinical outcomes of surgically managed ectopic ureters in 33 dogs. *J Am Anim Hosp Assoc.* 2011;47:196-202.

[15] Sutherland-Smith J, Jerram RM, Walker AM, et al. Ectopic ureters and ureteroceles in dogs: presentation, cause, and diagnosis. *Comp Contin Educ Pract Vet.* 2004;26:303-310.

[16] McLoughlin MA, Chew DJ. Diagnosis and surgical management of ectopic ureters. *Clin Tech Small Anim Pract.* 2000;15:17-24.

[17] Koie H, Yamaya Y, Sakai T. Four cases of lowered urethral pressure in canine ectopic ureter. *J Vet Med Sci.* 2000;62:1221-1222.

[18] Holt PE. Urinary incontinence in the bitch due to sphincter mechanism incompetence: prevalence in referred dogs and retrospective analysis of sixty cases. *J Small Anim Pract.* 1985;26:181-190.

[19] Holt PE. Urinary incontinence in dogs and cats. *Vet Rec.* 1990; 127:347-350.

[20] Holt P. Urinary incontinence. In: Holt P, ed. *Urological Disorders of the Dog and Cat: Investigation, Diagnosis and Treatment*. London, UK: Manson Publishing; 2008:134-159.

[21] Burdick S, Berent AC, Weisse C, et al. Endoscopic-guided ablation of vestibulovaginal septal remnants in dogs: 36 cases (2007-2011). *J Am Vet Med Assoc.* 2014;244:944-949.

[22] Callard J, McLoughlin MA, Byron JK, et al. Urinary incontinence in juvenile female soft-coated Wheaten terriers: hospital prevalence and anatomic urogenital anomalies. *J Am Anim Hosp Assoc.* 2016;52:27-35.

[23] Rosin AE, Barsanti JA. Diagnosis of urinary incontinence in dogs: role of the urethral pressure profile. *J Am Vet Med Assoc.* 1981;178:814-822.

[24] Richter KP, Ling GV. Clinical response and urethral pressure profile changes after phenylpropanolamine in dogs with primary sphincter incompetence. *J Am Vet Med Assoc.* 1985;187:605-611.

[25] Holt PE. "Simultaneous" urethral pressure profilometry: comparisons between continent and incontinent bitches. *J Small Anim Pract.* 1988;29:761-769.

[26] Adams WM, Di Bartola SP. Radiographic and clinical features of pelvic bladder in the dog. *J Am Vet Med Assoc.* 1983;182: 1212-1217.

[27] Gregory SP, Parkinson TJ, Holt PE. Urethral conformation and position in relation to urinary incontinence in the bitch. *Vet Rec.* 1992;131:167-170.

[28] Holt PE. Importance of urethral length, bladder neck position and vestibulovaginal stenosis in sphincter mechanism incompetence in the incontinent bitch. *Res Vet Sci.* 1985;39:364-372.

[29] Krawiec DR. Diagnosis and treatment of acquired canine urinary incontinence. *Companion Anim Pract.* 1989;19:12-20.

[30] Arnold S, Arnold P, Hubler M, et al. Urinary incontinence in spayed female dogs: frequency and breed disposition. *Schweiz Arch Tierheilkd.* 1989;131:259-263.

[31] Trebacz P, Jurka P. Short-term outcome following concurrent surgical treatment of ureteral ectopia and intrapelvic urinary bladder in nine neutered bitches. *Vet Rec.* 2013;172:663.

[32] Adams WM, Di Bartola SP. Radiographic and clinical features of pelvic bladder in the dog. *J Am Vet Med Assoc.* 1983;182: 1212-1217.

[33] Holt PE. Long-term evaluation of colposuspension in the treatment of urinary incontinence due to incompetence of the urethral sphincter mechanism in the bitch. *Vet Rec.* 1990;127:537-542.

[34] Hayes HM. Breed association of canine ectopic ureter: a study of female cases. *J Small Anim Pract.* 1984;25:501-504.

[35] Christie BA. The ureterovesical junction in dogs. *Invest Urol.* 1971;9:10-15.

[36] Mason LK, Stone EA, Biery DN, et al. Surgery of ectpic ureters: pre- and post-operative radiographic morphology. *J Am Anim Hosp Assoc.* 1990;26:73-79.

[37] North C, Kruger JM, Venta PJ, et al. Congenital ureteral ectopia in continent and incontinent-related Entlebucher mountain dogs: 13 cases (2006-2009). *J Vet Intern Med.* 2010;24:1055-1062.

[38] Fritsche R, Dolf G, Schelling C, et al. Inheritance of ectopic ureters in Entlebucher mountain dogs. *J Anim Breed Genet.* 2014; 131:146-152.

[39] Holt PE. Urinary incontinence in the dog. *In Pract.* 1983;5:162-173.

[40] Gregory SP. Urinary incontinence. In: Brainbridge J, Elliott J, eds. *BSAVA: Manual of Canine and Feline Nephrology and*

Urology. Gloucestershire: British Small Animal Veterinary Association; 1996:42-51.

[41] Ali-El-Dein B, Ghoneim MA. Effects of selective autonomic and pudendal denervation on the urethral function and development of retention in female dogs. *J Urol.* 2001;166:1549-1554.

[42] Theus R, Arnold S, Hubler M, et al. Effect of intra-abdominally induced pressure on the urethral pressure profiles of healthy and incontinent bitches. *Am J Vet Res.* 1997;58:555-559.

[43] Rawlings C, Barsanti JA, Mahaffey MB, et al. Evaluation of colposuspension for treatment of incontinence in spayed female dogs. *J Am Vet Med Assoc.* 2001;219:770-775.

[44] Gregory SP, Holt PE. Effect of body position on intravesical pressure in the anaesthetised bitch. *Vet Rec.* 1992;130:288-290.

[45] Rawlings CA. Colposuspension as a treatment for urinary incontinence in spayed dogs. *J Am Anim Hosp Assoc.* 2002;38:107-110.

[46] Augsburger HR, Cruz-Orive LM. Stereological analysis of the urethra in sexually intact and spayed female dogs. *Acta Anat (Basel).* 1995;154:135-142.

[47] Ponglowhapan S, Church DB, Khalid M. Differences in the proportion of collagen and muscle in the canine lower urinary tract with regard to gonadal status and gender. *Theriogenology.* 2008; 70:1516-1524.

[48] Augsburger H, Oswald M. Immunohistochemichal analysis of collagen types I, III, IV and alpha-actin in the urethra of sexually intact and ovariectomized beagles. *Int Urogynecol J.* 2006; 18:1071-1075.

[49] Arnold S. Urinary incontinence in spayed bitches. Part 1: significance, clinical features and aetiopathology. *Schweiz Arch Tierheil kd.* 1997;139:271-276.

[50] Nickel R. *Studies on the Function of the Urethra and the Bladder in Continent and Incontinent Female Dogs* [PhD thesis]. Utrecht University; 1998.

[51] Reichler IM, Pfeiffer E, Piche CA, et al. Changes in plasma gonadotropin concentrations and urethral closure pressure in the bitch during the 12 months following ovariectomy. *Theriogenology.* 2004;62:1391-1402.

[52] Salomon JF, Gouriou M, Dutot E, et al. Experimental study of urodynamic changes after ovariectomy in 10 dogs. *Vet Rec.* 2006;159:807-811.

[53] Thrusfield MV. Association between urinary incontinence and spaying in bitches. *Vet Rec.* 1985;116:695.

[54] Noel SM, Farnir F, Hamaide AJ. Urodynamic and morphometric characteristics of the lower urogenital tracts of female Beagle littermates during the sexually immature period and first and second estrous cycles. *Am J Vet Res.* 2012;73:1657-1664.

[55] Owen RR. Canine ureteral ectopia: a review. 2. Incidence, diagnosis and treatment. *J Small Anim Pract.* 1973;14:419-427.

[56] Tanagho EA. Embryologic basis for lower ureteral anomalies: a hypothesis. *Urology.* 1976;7:451-464.

[57] Mackie GG. Abnormalities of the ureteral bud. *Urol Clin North Am.* 1978;5:161-174.

How to cite this article: Noël SM, Claeys S, Hamaide AJ. Surgical management of ectopic ureters in dogs: Clinical outcome and prognostic factors for long-term continence*. *Veterinary Surgery.* 2017;46:631-641. https://doi.org/10.1111/vsu.12654