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Title: Long-term outcome of female dogs treated with static hydraulic urethral sphincter for urethral sphincter mechanism incompetence

Cesar A. Gomes, DVM; Ivan C. P Doran, BVSc, Edward J. Friend BVetMed, Michael S .Tivers, BVSc, PhD, Guillaume P. Chanoit, DEDV,PhD

From the University of Bristol, Faculty of Health Science, School of Veterinary Sciences

Address correspondence to Dr. Guillaume Chanoit (g.chanoit@bristol.ac.uk)

Short title: Outcome of dogs treated with static hydraulic urethral sphincter

The purpose of the study was to report the postoperative outcome, complications and long-term follow-up of the use of a static hydraulic urethral sphincter (SHUS) for the management of urethral sphincter mechanism incompetence (USMI) in female dogs. Medical records were reviewed to extract information on long-term (>365days) outcome data. Telephone owner questionnaire was performed to assess post-operative urinary continence scores (scale 1 to 10, where 10 is complete continence) and the presence and frequency of complications. Twenty female dogs were included. Mean (±SD) time to follow-up was 1205.1 (±627.4) days. Median continence score/10 (range) was 3.5 (2-6) preoperatively, and 9.0 (7-10) at the last follow up. Median continence score was significantly higher at all-time points post-operatively compared to before surgery ($P<0.001$). Complete continence was achieved in 90% of bitches. Minor complications occurred in 13 bitches and included dysuria (8), bacterial cystitis (8), longer urination time (10), incisional seroma (5), urinary retention (3), hematuria (2) and pain when urinating (2). Major complications occurred in one dog (SHUS removed 28 months after placement). Continence scores were sustainably improved in the

long-term. Complications were mostly minor. Urinary tract infection (UTI) were the most common but resolved with conventional antibiotic treatment.

Introduction

Urinary incontinence in dogs is commonly seen in veterinary practice. [1] USMI is the most common cause of acquired urinary incontinence in female dogs,[1] and it is also seen, less commonly, in males. [2] USMI is a multifactorial condition. Contributory factors include urethral tone, urethral length, bladder neck position, hormonal status, neutering status, obesity, body size and breed.[3] Medical management with α-adrenergic agonists, such as phenylpropanolamine (PPA) or ephedrine, increases sympathetic bladder neck tone and has been shown to increase maximal urethral closure pressure in cases of urethral sphincter mechanism incompetence. [4] It has been shown to improve urinary incontinence in acquired USMI in up to 85% of dogs. However, between 15 and 27% of female dogs with USMI cases remain refractory to medical management with PPA. [4 5] The same percentage of refractory cases is also found following treatment with estriol. [6]

Surgical management of USMI is recommended when medical management fails or if long-term medical management is not an option. Several different procedures are described for controlling USMI in bitches including colposuspension, [7 8 9] urethropexy [10 11] or a combination of both, [12] urethral submucosal injections with either collagen, [13 14 15] polytetrafluoroethylene (PTFE) [16] or extracellular matrix bioscaffold, [17] transobturator vaginal tape inside out , [18 19] Dacron coated Silastic sheet urethral sphincter, [20] and most recently, SHUS. [21 22 23,24] Complications reported with these techniques include persistent incontinence (immediate or delayed), dysuria, urinary obstruction, haematuria and recurrent UTI. [8 11 13 13 15 14 23 21]

The Static Hydraulic Urethral Sphincter (also known as artificial urethral sphincter) is a silicone device surgically placed around the urethra. It can be incrementally inflated post-operatively, via a subcutaneous port, to progressively compress the proximal urethra and achieve continence. Should dysuria result, the SHUS can also be partially or fully deflated. [22] SHUS has been investigated in bitches that have ongoing or recurrent incontinence after surgery. A preliminary in vivo experimental study, [25] followed by a clinical pilot study in four spayed bitches, [22] showed good results up to two years post-operatively, with all dogs achieving full continence at last follow-up at 26 to 30 months. A larger study (27 dogs, including three male dogs) was published by the same institution and improved incontinence scores were seen in all dogs, with a median follow up of 12.5 (6-19) months. [23] This series also reported minimal complications. The authors of the present study have also previously reported high success rates and low complication rates for this technique at their institution but only with a short-term follow-up;[21] several reports have defined long-term follow-up as follow- up of 12 months and over. [26 7] To our knowledge, no studies to date have described long-term follow-up (> 12 months) of female dogs treated for USMI with SHUS implantation.

The primary aim of this study was therefore to report the long-term (>12 months) outcome of SHUS for the control of USMI in female dogs. A second aim was to document any long-term complications and therefore assess the ongoing safety of the SHUS in dogs with naturally occurring disease.

Material and Methods

Inclusion criteria

The study was approved by our institutional Ethical Review Committee. Clinical records and histories were reviewed for female dogs presenting to the authors institution between January 2009 and December 2015 for evaluation of urinary incontinence. History, physical examination, routine biochemical and haematological analysis, abdominal ultrasound, urinalysis, urine culture, intravenous contrast urography (IVU) and contrast retrograde vaginourethrocystogram ± cystoscopic examination were performed in all dogs to rule out other causes of urinary incontinence. Dogs that were presented with concurrent UTI were treated with antibiotics selected according to anti-microbial susceptibility testing. USMI was diagnosed if the incontinence persisted after negative urine culture and imaging of the urogenital tract disclosed no significant anatomical abnormalities other than an intrapelvic bladder neck location consistent with USMI. Inclusion criteria included all females in which a SHUS was placed for the treatment of USMI where adequate records were available. Animals were excluded if their follow-up was less than 12 months. Long-term follow-up was assessed by a questionnaire to owners and or referring veterinarian.

Surgical Procedure

All dogs were investigated and treated at the author's institution and surgery was performed by a board-certified surgeon or a surgical resident under the direct supervision of a board-certified surgeon. Surgery was performed as previously described. [21 22]

Postoperative care

Dogs were administered 0·2 to 0·3 mg/kg methadone intravenously (IV) or intramuscularly (IM) q 4 hr or 0·01 to 0·02 mg/kg buprenorphine IM or subcutaneously q 6 hr to q 8 hr postoperatively as required (based on pain assessment) and 0·1 mg/kg meloxicam[b] q 24 hr orally postoperatively for analgesia. Perioperative antibiosis was administered in the form of potentiated amoxicillin[c], 20 mg/kg q 2 hr during anaesthesia, followed by five days of 20 mg/kg potentiated amoxicillin[d] orally in some dogs. The sphincter was not inflated at the time of placement.

Follow-up

Follow-up intervals varied and any procedures performed at these examinations were dictated by the needs of each individual dog. Typically dogs were requested to return to the institution for a routine re-examination six to eight weeks postoperatively. At this re-examination the overall continence rate was assessed, and the presence and severity of dysuria, stranguria, haematuria, wound inflammation or infection and length and character of micturition were determined by close questioning of the owners and direct observation of the dog urinating by the examining veterinary surgeon. Remaining follow-up examinations were performed by referring veterinarians or the institution as required.

Dogs exhibiting dysuria, pain on urination or suspicion of UTI on routine re-examination or on communication with the owner were admitted for repeat urinary tract ultrasound examination. Postoperatively, only dogs which remained incontinent had urine sampled for culture and sensitivity. A urine sample was obtained by cystocentesis and was submitted for urinalysis and/or urine bacterial culture and antibiotic sensitivity. Where UTI (positive bacterial culture or active sediment on urinalysis) was identified, treatment was instigated with appropriate antibiotics based on susceptibility testing, where possible, until a negative urine culture was obtained. Upon documentation of a negative urine culture, and if the animal was still showing signs of incontinence, the SHUS was inflated by one injection of 0·1 to 0·5 mL of sterile isotonic (0·9%) sodium chloride (NaCl) into the port following a protocol, previously described.[21]

Complications were identified and categorized as major or minor using criteria similar to those previously published. [21]Briefly, major complications included those requiring replacement of the SHUS system. Minor complications were defined as those that did not necessitate replacement of the SHUS, and were often self-limiting.

Follow-up questionnaire

Owners and referring veterinarians were contacted and asked to complete a telephone questionnaire(s) assessing the postoperative progress of the dogs (December 2015). Where owners could not be contacted, questionnaires were completed where possible based on referring veterinarian records. Continence levels were scored using a scale ranging from 1 (constant leakage) to 10 (complete continence), before surgery and at set time points postoperatively (at discharge, six and 12 months postoperatively, and at the time of the last questionnaire). Details of the scale are given in the appendix 1. Scores of <8 were classified as 'incontinent', whereas scores of 8 or more were classed as 'continent'. Scores were dichoto-

mized this way for easier interpretation in terms of clinical relevance, based on what owners' perceive to be acceptable levels of continence. Additionally, owners were asked to grade in severity (0-3) any complications pertaining to urination noted following surgery, or related to the implants. A score of 0 indicated that no complications were seen, and scores of 1, 2 and 3 indicated mild, moderate and severe complications, respectively. The significance of a mild, moderate or severe events was illustrated by giving precise examples to owners when completing the questionnaire over the phone. Finally, owners were asked to score their satisfaction with their dog's outcome from 1 (very unsatisfied) to 10 (very satisfied), and asked whether they would have the procedure performed again if they had another dog with the same problem. Where dogs were euthanized or died before being contacted, owners were asked to answer the questionnaire based on their latest recollection of their dog's status (at the time of death).

Statistical analysis

Statistical analysis was performed by use of a commercial software.[f] Data were tested for normality using Kolmogorov-Smirnov tests; age, body weight and time to follow-up were normally distributed and were reported as the mean (SD); duration of hospitalization, owner satisfaction scores and continence scores were not normally distributed and reported as median (range). A Friedman test for repeated measures was first performed to assess any overall difference between the repeated continence scores on each subject, pre-operatively with those at discharge, 6 months, and 12 months and at last follow-up. Given an overall significance, differences between paired time points were then assessed using a paired-samples sign test. P value $<0{\cdot}05$ was considered significant.

Results

Twenty female dogs met the inclusion criteria. Eighteen were 18 spayed and two entire. Table 1 shows the signalment, preoperative treatment, diagnostic imaging findings and cuff size used along with their respective volumes of total inflation. Mean age was 61.0 months (±24.0) and median weight was 27.7 kg (9.6 - 62.7 kg). All included spayed female dogs were first noticed to be incontinent soon after routine ovariohysterectomy (days to weeks). Seventeen of the twenty dogs had either failed to respond completely to medical management with one or more of a combination of PPA, estriol or ephedrine, or had initially responded but then become incontinent despite medication. None of the dogs had experienced adverse effects attributable to medication. Dog 13 did not receive any medical treatment for USMI prior to surgical treatment as the owner wished to pursue surgery only. Dogs two and 10 were selected for surgery despite adequate medical control of incontinence due to difficulties with administering medication. Physical examination and diagnostic imaging revealed urogenital abnormalities in 11/20 dogs (Table 1). No dog had a UTI at the time of sur-

gery, based on the results of urinalysis and bacteriology assessment. Median pre-operative continence score was 3.0 (2-6).

No intraoperative complications were encountered during surgery, and all dogs were urinating without difficulty the following day, although 12/20 remained incontinent at discharge (Table 2). Median immediate postoperative continence score (8.0 (2-10)) was significantly higher than median pre-operative score ($P<0.001$). Median postoperative hospitalization time was 2 days (1 to 3 days).

Median continence scores at 6- and 12-months postoperatively were 8.5 (4-10) and 9.0 (5-10) respectively. These were both significantly higher than preoperatively scores ($P<0.001$). Mean time at latest follow-up was 1205.4 days (627.4) (Table 2). At this time, 80% of dogs (16) were continent without any other treatment, 10% of dogs (two) were continent and on continued medical therapy (dogs 3 on 1mg estriol q 24 hr and PPA and dog 14 on PPA and estriol) and two dogs were judged incontinent based on lower continence scores (both had continence scores of 7). Continence score was 9.0 (7-10) and was significantly higher than pre-operatively ($P<0.001$). Communication was not possible with the owners of four dogs (dogs 9, 13, 19 and 20) at the time of latest follow-up and therefore, information were gathered through communication with the referring veterinarian. Over the study period, 4/20 dogs (dogs 1, 2, 6 and 12) were euthanized for reasons unrelated to USMI. All of these dogs had a follow-up time >12 months before euthanasia.

Regarding management of ongoing incontinence, one dog (dog 8) received a course of PPA to control persistent post-operative incontinence, as the authors were reluctant to inflate the cuff in this dog due to concurrent dysuria. Dysuria resolved without treatment after several weeks and incontinence subsequently resolved with inflation of the SHUS and cessation of the PPA. Seven of the 20 dogs (35%) did not require any inflation of the SHUS. Thirteen required inflation and four of these dogs required subsequent deflation of the cuff, due to

urinary retention (dog 1), severe dysuria (dogs 2 and 6), or urethral obstruction (dog 11). Two dogs (dogs 1 and 2) had their cuff completely deflated, and two dogs (dogs 6 and 11) had partial deflation (see Table 2 for details).

Minor complications were reported in 13/20 dogs (65%) and are further detailed in Table 3. Complications were experienced at a variety of times postoperatively. All complications, with one exception, were minor. One dog (dog 1) experienced a major complication event and required surgical intervention for SHUS removal 28 months postoperatively due to persistent post-operative stranguria. Seven dogs had postoperative UTIs. One additional dog (dog 10) had a UTI before (but not at the time of surgery) and after surgery. *E.coli* infection was initially identified in this dog, which was sensitive to and treated with amoxicillin/clavulanic acid. Persistent recurrent dysuria was reported post-operatively and this was treated presumptively by the referring veterinarian with amoxicillin/clavulanic acid. Culture and sensitivity was then performed six days postoperatively; Multi-drug resistant (MDR) *Escherichia coli*, Enterobacteriae and Pseudomonas *spp*. were identified which were sensitive to amoxicillin/clavulanic acid. For all other dogs where a UTI was suspected based on clinical signs, urinalysis and a positive response to antibiotics, no culture and sensitivity information was available. Pain surrounding the subcutaneous port, which was responsive to analgesia, was noted in two dogs during the first two to three weeks postoperatively.

Median owner satisfaction score was 9.5 (5-10). All but one owner, who said he was unsure (dog 15, satisfaction score of 8) said that they would have the procedure performed again if they had another dog with the same problem. We also noted lack of compliance with our recommendations (i.e. owner unwilling to come back for cuff inflation) from two owners. Those were the dogs with the lower continence scores at follow up (continence score of 7).

Discussion

This retrospective study reports the long-term outcome of SHUS for the management of USMI in female dogs, with a longer time to follow-up (mean 40 months) than has previously been described (26-30 months [22]; 13.5 months; [21] 12.5 months; [23] 32 months [24]). It is important to document long-term efficacy of surgical techniques for USMI, as, for example, dogs treated with urethral injections of collagen showed good initial success, but over half of dogs become incontinent approximately 12-16 months postoperatively [14 15] and PTFE injections had an initial 100% success rate but many dogs developed recurrent incontinence over time. [14] It is vital that veterinarians have a good understanding of the likely outcomes of the technique and are aware of the possible short- and long-term complications. The long-term continence rate is higher (90% with 2 cases having medical management) than for colposuspension (53% and 37% being improved or more responsive to medical treatment), [7] urethropexy (56%) [11] or combination of both (70%) [12] or urethral bulking agents (68%); [14] mean follow up in the latter two studies was comparable to this study at around three years. Furthermore, the two dogs classed as incontinent (continence scores <8) did not have a proper cuff management due to lack of owner compliance. Avoiding the financial costs associated with ongoing medical management and expensive repeat surgery is a benefit of SHUS placement compared to other techniques (only one dog required repeat surgery in this study). Another major benefit of the SHUS that is not possible with any other reported technique is the flexibility provided by the ability to inflate or deflate the SHUS at any stage following surgery, in a conscious dog with minimal equipment. Importantly, owner satisfaction scores were very high in this study and all but one owner agreed that they would have the same treatment performed again. This is similar to owner satisfaction reported in an other study [23] where 24/27 owners were satisfied or very satisfied with the procedure.

In the authors' experience the surgical procedure is simple to perform and requires minimal additional specialized equipment, apart from the implants and a non-coring Huber

needle. Certain aspects of the technique, however, require special attention. Care must be taken to avoid bubble formation in the system and to ensure adequate slack is left in the tubing to avoid kinking of the SHUS at the urethra. Secure attachment of the tubing to the injection port is also particularly important. Finally, close monitoring of the dog for at least 24 hours postoperatively for ease and character of urination is essential.

SHUS can be used to treat dogs with incontinence due to multiple different causes other than USMI [24] and in males dogs with USMI. [23] We have purposely decided to restrict this study to the female population of dogs treated for USMI (which is the most common cause of incontinence seen in our hospital). We believed that adding male dogs or dogs presented for urinary incontinence due to conditions other than USMI would add variability and have weakened the conclusions of the present report.

Ninety percent of our dogs (where two are being managed medically) achieved continence at long term follow up, similar to Currao et al. study [24] where all 18 dogs had significantly improved continence scores immediately after SHUS placement, and 67% with continence scores > 9 at long term follow up. A median continence score of 9 out of 10 at last follow-up was reported by Reeves et al.[23] In Rose et al. study [22] all dogs were continent after the placement of the SHUS (including one dog on medical management for a few months to maintain a continence score 9 out of 10) and were continent at mean latest follow-up of 30 months without complications. The two dogs on medical management post-operatively in this study achieved good continence scores, despite not being responsive to medical management before surgery. They were not completely continent as their owners decided to not pursue further inflations and decided to continue with medication; the authors believe it is likely that medications could have been stopped if further cuff inflation had been performed.

Despite the SHUS being left uninflated at the time of surgery (only a small residual primer volume was used to fill the tubing and injection port), 85% dogs showed improved

continence immediately after surgery. A period of 6-8 weeks was allowed between surgical placement and inflation of the SHUS based on previous recommendations in human and veterinary studies. [22 27] This is proposed to allow adequate revascularization of the dissected urethra and minimize the risk of urethral atrophy and erosion. The immediate postoperative improvement in continence seen in this study was also appreciated in previous reports. [22 23] It is hypothesized that this occurs due to the passive increase in urethral tone created by the presence of the semi-rigid backing on the urethral part of the implant. [22 23] Similar to our results (7 dogs, 35%) 33% of dogs reported by Currao et al. [24] did not require inflation to achieve continence.

Only one major complication was reported in the current case series, (one dog that had to have the SHUS removed) in agreement with previous reports of the SHUS technique. [22 23] One or more minor complications occurred in 65% dogs, a lower incidence than in our previous study (81.8%).[21] This report included the first 11 dogs of the current study, suggesting that complication rate has improved with more experience of the technique. Although complications were encountered more commonly than reported with other techniques, [7 11] they were minor and self-limiting. Only one dog required further surgery to remove the cuff, 28 months after it was placed. This dog was moderately persistently stranguric despite complete deflation of the cuff. Postoperative or post-cuff inflation stranguria was seen in seven additional cases. Deflation of the SHUS was performed, resulting in resolution of stranguria in all dogs without further intervention. This is a similar experience to stranguric dogs previously reported. [22] The severity of the stranguria and the presence of urinary retention were considered when determining whether cuff deflation was indicated. It was thought in retrospect that stranguria was caused by overinflation of the cuff in dog 1, where 33% of the total cuff volume was instilled initially. In subsequent dogs, a more gradual SHUS inflation (10 to 20% increments) was therefore performed to reduce the risk of stranguria, in line with the

recommendations by Rose et al. [22] Reeves et al. [23] reported mild stranguria seven to ten days after surgery in five dogs, which responded to non-steroidal anti-inflammatories in all animals. Stranguria and anuria are reported complications of colposuspension and urethropexy, requiring postoperative catheterisation in the case of colposuspension and repeat surgery and suture removal in urethropexy. [7 11] Martinoli et al. reported dysuria in some dogs where both techniques were combined.[12] When these complications occur following SHUS placement, this study shows that they are more easily and less invasively managed than with the two aforementioned techniques.

The most common complication in this population appeared to be post-operative UTIs. According to a study by Wong et al., dogs that had one or two single events of UTI documented were consider to have uncomplicated UTIs which may even have been related to USMI.[28] Olin and Bartges proposed that all dogs with UTIs related to USMI would be called complicated. [29] UTIs occurred in eight cases out of 20 dogs (40%), based on a combination of urinalysis, positive urine bacterial culture and response to antibiotics. This is a significant proportion of dogs, although two out of eight cases where information was available had single UTIs. Three dogs had multiple (three and over) UTI events and in these animals the authors consider that they had complicated UTIs. Due to lack of records, the nature of these infections (for example if they involved the same organism, or MDR organisms and whether or not significant clinical signs were associated) was unknown. All UTIs were successfully treated with antibiotics based on resolution of clinical signs. It is clear that more information is needed regarding the association between SHUS and UTIs as it is possible that some of the cases of UTIs post SHUS placement may simply be related to the higher prevalence of UTIs in incontinent female dogs and not necessarily linked with the presence of the SHUS. Only a more stringent protocol involving routine urine culture and sensitivity irrespective of the presence of clinical signs could provide information on the prevalence of subclinical infec-

tions. We can therefore not exclude the presence of subclinical infection in some of the dogs included in this study as only dogs with clinical signs consistent with UTIs were further investigated with urine culture and sensitivity.

. Because pain surrounding the subcutaneous port was noted in two dogs during the first two to three weeks postoperatively, the authors modified the port placement technique by moving the location of the port from the medial musculature of the pelvic limb/inguinal region to the paramedian abdominal wall. Pain was not suspected in any subsequent dog, and that location of the port allowed it to be more easily identified on palpation and also likely reduced port movement.

Prolonged duration of micturition compared to that preoperatively was reported in 50% dogs. This is far less frequent than that noted in a previous study where three out of four animals (75%) presented with this complication. [22] To the authors' knowledge, this is not a reported complication following colposuspension or urethropexy and is considered a more severe form of prolonged emptying. The significance of prolonged micturition in these dogs is unknown but may indicate discomfort when urinating, or smaller urethral diameter due to the SHUS placement and rather inelastic fibrous tissue formation around the urethra at this particular level.

One dog had a known obstructive episode (managed by slight cuff deflation) and three additional dogs had suspected low-grade ongoing urinary retention. Although urinary retention did not result in obvious additional complications, it is a known risk factor for UTI development. This may contribute to UTI development in dogs treated with SHUS cases, although this case series is too small to allow this association to be evaluated fully. It is now considered prudent to counsel owners regarding the potential postoperative risks of urinary retention. We recommend that the bladder is routinely checked post-micturition (by palpation and/or ultrasound examination) by the referring veterinarian every three months during the

first year postoperatively and then as required, based on the initial presence or degree of urinary retention.

This study has a number of limitations, primarily due to its retrospective nature. Some data were reliant on owner recall ability and in any case were subjective, despite efforts to classify continence scores and complication severity on numeric scales. Inter-observer variability and bias were unavoidable disadvantages of data collection by owner questionnaire. Owner satisfaction would also have depended on pre-existing expectations, influenced by preoperative counseling, owner education, understanding of the procedure and expected outcome. A contemporaneous record of the continence levels, recorded at the specified time intervals, would be more reliable. This said, owners' perceptions are increasingly being recognized as important outcome indicators, rather than using objective scientific criteria alone. [30] Additionally, bacteriuria may have been missed due to clinical signs only prompting further investigations for a possible infection.

Conclusion

Overall, SHUS is an effective treatment for USMI in bitches, resulting in a significant improvement in continence scores, in both the short- and long-term (>12 months). This study shows that 90% of dogs achieve continence and that owners were very satisfied with their dogs' outcome. It confirms that a major advantage of the SHUS is that it provides scope for potentially further improving continence postoperatively (without surgery and without further medication) by cuff inflation, although this is not required in all dogs. According to this study, long-term management of SHUS does not seem to result in a high incidence of implant –related complications. Results are of importance as they add to the currently limited body of evidence available for veterinarians regarding the use of SHUS.

Footnote list

a : Prolene, Ethicon, Norderstedt, Germany

b : Metacam, Boehringer Ingelheim Ltd, Bracknell, UK

c: Augmentin, GlaxoSmithKline, Brentford , UK

d: Clavaseptin, Vetoquinol UK Ltd Buckingham, UK

e: Access Technologies, Skokie, IL

f: Systat, version 10.0, SPSS Inc, Chicago, Ill

PPA: phenylpropanolamine

USMI: Urethral sphincter mechanism incompetence

UTI: urinary tract infection

SHUS: static hydraulic urethral sphincter

PTFE: polytetrafluoroethylene

IVU: intravenous contrast urography

IV: intravenously

IM: intramuscularly

MDR: multi-drug resistant

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Table 1: Signalment, preoperative findings and inflation/deflation volumes for SHUS for 20 female dogs.

Dog	**Breed**	**Body weight (Kg)**	**Age at surgery (months)**	**Preoperative treatment**	**Imaging findings**	**SHUS size (mm) (total volume, ml)**
1	Irish Setter	31.9	100	PPA	Intrapelvic bladder	12 (1.5)
2	Rottweiller X	52.3	31	PPA / estriol	NSF	10 (1.45)
3	Labrador	27.5	84	Ephedrine	Intrapelvic bladder	10
4	Irish Setter	32	63	PPA / estriol	Intrapelvic bladder	10 (0.9)
5	WHWT	9.6	54	PPA / estriol	NSF	6 (1)
6	Border Collie	23.5	80	PPA / estriol	Pyelectasia and intrapelvic bladder	8 (1)
7	Springer Spaniel	14.5	88	PPA / colpo	Mild vaginal stricture	8 (1)
8	Dobermann	38.3	33	PPA	Intrapelvic bladder and perivulvar dermatitis	10 (0.8)
9	Labrador	24.5	72	PPA / estriol	NSF	10 (0.8)
10	Labrador	27.9	77	PPA/ estriol	NSF	10 (1.2)
11	Dobermann	34.8	60	PPA / estriol	NSF	10 (2)
12	Dobermann	27.9	72	PPA / estriol	Intrapelvic bladder	12 (1.5)
13	Great Dane	62.65	23	None	Intrapelvic bladder	10 (1.2)
14	Boxer	24.9	60	PPA / estriol	NSF	10 (1)
15	Weimaraner	25.6	83	PPA	Intrapelvic bladder	10 (2)
16	Springer Spaniel	22.5	80	PPA / estriol	NSF	10 (1.2)
17	Mastiff	40.1	26	PPA	Intrapelvic bladder	10 (1.2)
18	Labrador	25	36	PPA / estriol	NSF	10
19	Dobermann	31.3	25	Estriol	Mild renal dysplasia and intrapelvic bladder	10
20	Collie X	25	73	PPA / estriol	NSF	10
Mean		**30.1**	**61**			
S.D.		**11.8**	**24.0**			

NSF- no significant findings; PPA- phenylpropanolamine; Colpo- colposuspension; WHWT- west highland white terrier; S.D.-standard deviation

Table 2: Owner-rated continence scores, total number and volume of inflations/deflations performed and time at last follow-up.

Dog	Continence score (0-10)					Total number of inflations (total volume of inflation, mL)	Total number of deflations (total volume of deflation, mL)	Time at last follow-up (days)
	Pre- op	Discharge	6-months	12-months	Latest follow-up			
1	2	4	4	10	10 (PTS)	3 (0.75)	2 (0.75)	1279
2	4	10	6	7	7 (PTS)	1 (0.3)	1 (0.1)	428
3	6	8	10	5	9*	4 (0.5)	0	2044
4	3	2	10	10	9	0	0	1884
5	3	3	7	7	8	1 (0.2)	0	1853
6	6	8	5	9	10 (PTS)	4 (0.8)	1 (0.2)	1095
7	4	10	8	8	8	0	0	1779
8	2	6	8	8	9.5	2 (0.4)	0	1519
9	3	8	8	9	9	0	0	1090
10	5	6	10	10	10	9 (1.05)	0	790
11	2	2	4	9	8	6 (0.65)	1 (0.35)	454
12	2	4	10	10	10 (PTS)	5 (0.65)	0	365
13	6	8	10	10	10	0	0	1424
14	2	9	10	10	10*	0	0	808
15	2	9	8	8	7	3 (0.5)	0	806
16	2	9	10	10	10	1 (0.15)	0	559
17	2	9	9	9	8	1 (0.15)	0	1290
18	6	10	9	9	10	0	0	2257
19	2	5	9	9	9	0	0	2093
20	6	9	8	8	8	1 (0.15)	0	365
Median	**3.0**	**8.0**	**8.0**	**9.0**	**9.0**		**Mean**	**1205.4**
Range	**2-6**	**2-10**	**4-10**	**5-10**	**7-10**		**SD**	**627.4**

PTS=euthanized, *dogs also receiving medical management

16 Table 3: Severity scores (0-3 in increasing severity) of complications following SHUS

17 placement.

Dog	**Urinary complications**								**Wound / port complications**		
	Stranguria	Haematuria	Urinary infection			Pain on Urination	Longer micturition time	Seroma	Infection	Pain	Healing
			Score	When occurred	Number of events						
1	2	0	1	Post operatively	Single event	0	2	1	0	0	0
2	3	2	3	Post operatively	Multiple events	2	3	0	0	0	0
3	0	0	0			0	1	0	0	0	0
4	0	0	0			0	0	0	0	0	0
5	0	0	0			0	0	0	0	0	0
6	3	0	3	Post operatively	Multiple events	1	1	0	0	1	0
7	0	0	3	Post operatively	Multiple events	0	1	1	0	0	0
8	2	0	0			0	2	3	0	0	0
9	2	0	2	Post operatively	Single event	0	2	0	0	0	0
10	0	2	2	Pre and post operatively	Multiple events	0	0	0	0	0	0
11	1	0	0			0	2	0	0	0	0
12	1	0	0			0	1	0	0	0	0
13	0	0	0			0	0	0	0	0	0
14	0	0	1	Information not available	Information not available	0	1	0	0	0	0
15	0	0	0			0	0	0	0	0	0
16	0	0	0			0	0	1	0	0	0
17	0	0	0			0	0	0	0	0	0
18	3	0	2	Information not available	Information not available	0	0	1	0	0	0
19	0	0	0			1	0	0	0	2	0
20	0	0	0			0	0	0	0	0	0

18 Complication score = 0- none /complete healing, 1- mild, 2- moderate, 3-severe;

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