Immediate urodynamic and anatomic response to colposuspension in female Beagles

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Objective—To characterize urodynamic function and anatomy before and after colposuspension in anesthetized female Beagles.

Animals—12 adult female Beagles.

Procedure—During general anesthesia (thiopental sodium induction and halothane maintenance), urethral pressure profiles, leak point pressure measurements with a 50-ml bladder volume, positive contrast cystograms, and retrograde vaginourethrocystograms were performed. A caudal midline laparotomy was used to perform colposuspension. Urodynamic and radiographic studies were repeated after surgery.

Results—Leak point pressures were increased (120 to 168.9 cm H_2O), and maximum urethral closure pressures decreased (43.7 to 19.3 cm H_2O) after colposuspension. The urethra and bladder were moved cranially; the external urethral orifice was positioned closer to the pelvic cavity, and the neck of the bladder was positioned more cranially into the abdomen. Length of the urethra, as measured by use of vaginourethrocystograms, was increased by 3%. As measured by use of urethral pressure profiles, total profile length was increased by 19.9%, and functional profile length was increased by 19.2%.

Conclusions and Clinical Relevance—Increased leak-point pressure correlated with the expected clinical improvement attributable to colposuspension. Increased exposure of the urethra to abdominal and pelvic cavity pressures may be the mechanism by which incontinent dogs become continent after colposuspension. Results of the leak-point pressure test may correlate with clinical behavior before and after colposuspension for treatment of incontinence. (*Am J Vet Res* 2000;61:1353–1357)

Urinary incontinence is common in women and female dogs. Spayed female dogs commonly develop urinary incontinence attributable primarily to sphincter incompetence. Most dogs are treated medically with α-agonist or estrogen medication, but several series of dogs treated by use of colposuspension have been reported by Holt.[1-3] More than 50% of incontinent dogs are cured, and another 40% have decreased severity and frequency of incontinence after colposuspension. Median **maximum urethral closure pressure (MUCP)** was increased immediately after surgery,[4] but the **urethral pressure profile (UPP)** performed before surgery was not a prognostic criteria regarding which animals would be made continent.[2] In women, **leak-point pressure (LPP)** test results correlate well with severity of incontinence and response to treatment.[5-7] Stress incontinence in women occurs in response to sudden increases in abdominal pressure (laughter, sudden moves, coughing), whereas female dogs are usually incontinent during sleep or while recumbent.

When incontinence surgeries designed to elevate, suspend, and reposition the urethra (retropubic suspension, transvaginal suspensions, anterior repairs, and sling procedures) are performed in women, the goal is to reposition the hypermobile vagina and urinary outflow tract from the pelvic cavity to a more intra-abdominal position.[8] The rationale for this procedure is that the neck of the bladder returns to a zone of higher pressure, which adds occluding pressure to the outside of the neck of the bladder.[9] Although colposuspension is beneficial in controlling continence in incontinent female dogs, the rationale proposed for women does not seem to be as applicable for dogs, because dogs are quadrupeds and are more likely to be incontinent during recumbency, whereas women are more likely to be incontinent in an upright position during periods of high abdominal pressure. To better understand the mechanisms for improved urinary control, the purpose of the study reported here was to characterize urodynamic function and anatomy before and after colposuspension in anesthetized female Beagles.

Materials and Methods

Patient selection—This project was performed with the approval and under the guidelines of the Institutional Laboratory Animal Care and Use Committee of the University of Georgia.

Twelve mature female Beagles that weighed (mean ± SD) 15.5 ± 2.6 kg (range, 10.2 to 18.6 kg) were studied. These dogs were to be euthanatized after long-term nutritional or other studies; the study reported here was performed during general anesthesia before the dogs were euthanatized. Eight of 12 dogs were obese. In 7 of these dogs, estimates of body fat based on a dual energy X-ray[a] score were reported as increased above reference value.[b] Whether dogs were incontinent or not was not known, because the dogs were cage-raised and were reluctant to urinate during observation.

Anesthesia and surgery—Each dog was anesthetized by administration of thiopental sodium (12 to 15 mg/kg of body weight, IV) for induction and halothane gas for maintenance. Depth of anesthesia was monitored by determining eye position, palpebral reflex, withdrawal reflex of the hind limb after toe pinching, and jaw tone. Anesthetic depth was judged to be that of a surgical plane as indicated by central eye positioning, intact palpebral reflexes, absence of limb withdrawal, and presence of mandibular muscle (jaw) tone without

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active contractions. Urodynamic studies and contrast radiography were performed. A caudal midline laparotomy was used to approach the urinary bladder, urethra, and vagina. A colposuspension was performed by use of the method of Holt.[3] Two sutures of size 0 prolene were placed into the vaginal wall on both sides of the urethra. Each suture was placed in a cruciate fashion. Suture placement in the prepubic tendon was as lateral as possible, just medial to caudal superficial epigastric arteries and veins. The abdomen was closed so that the urodynamic and radiographic procedures could be repeated. After radiography, dogs were euthanatized by administration of pentobarbital sodium, and a necropsy was performed.

Urodynamic studies and contrast radiography—Before and after colposuspension, each dog had a UPP, LPP, positive contrast cystogram, and a retrograde vaginourethrocystogram performed in sequence. Urethral pressure profile and LPP measurements were performed with a computer-based urodynamic system.[c,10] After induction of anesthesia and with the dog positioned in right lateral recumbency, a sterile 8-F UPP catheter[d] was placed into the bladder via the urethra and connected to a pressure transducer leveled to the vulva. Sterile water was infused through a side port of the single-lumen catheter at 5 ml/min while pressure was measured through the end port. The catheter was withdrawn at 0.5 mm/s by a mechanical puller. Computer measurement was performed by marking the recording for baseline urinary pressure within the bladder, maximal urethral pressure, end urethral pressure, functional profile length, and total profile length.[6] The MUCP was calculated by subtracting the baseline pressure in the bladder from the maximal urethral pressure. The location of the MUCP within the urethra was determined by measuring the distance from the beginning urethral pressure to the MUCP and dividing it by the functional profile length.

Following the UPP, the dog was positioned in dorsal recumbency, the urethra was catheterized with a 6-F dual lumen urinary catheter,[e] and the bladder was emptied. A large indirect blood pressure cuff, as used for an adult human, was placed loosely around the middle region of the abdomen. It was not fastened or inflated until the transducers were balanced and baseline pressures recorded. The bladder was filled with sterile water at 50 ml/min until 50 ml had been infused. The abdominal pressure cuff was fastened and inflated to 80 mm Hg. Additional abdominal pressure was applied via 2 hands with one placed on top of the other; the palm of the lower hand was placed over the cuff to exert sufficient pressure to cause urine leakage from the vulva. Pressure measured at the time of initial urine leakage was recorded as LPP. At least 3 compressions that caused leakage were performed, and each LPP was recorded. If LPP exceeded the upper limit (200 cm H_2O) of the recording system, it was recorded as 200 mm H_2O. Following the LPP measurement, the cuff was removed, and the amount of pressure (bladder leak pressure) that caused leakage was determined when pressure was applied directly to the bladder by pressure exerted by both hands.

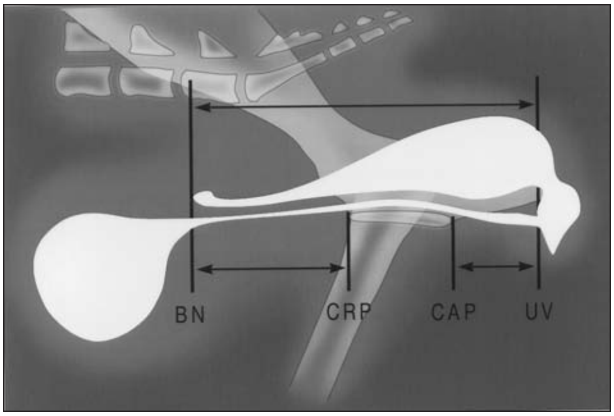

Figure 1—Illustration of urethral dimensions measured from retrograde vaginourethrocystograms in 12 Beagles. Measurements included the distance from bladder neck (BN) to the cranial aspect of the pubis (CRP), the distance from the caudal aspect of the pubis (CAP) to the external urethral orifice at the vagina (UV), and length of the urethra from the neck of the bladder to the external urethral orifice.

Following the last urodynamic study, 20 ml of iothalamate sodium[f] was added to approximately 45 ml of water that remained from the LPP study. A positive contrast cystogram was performed with the dog positioned on its left side. Then, a vaginourethrocystogram was performed by injecting an additional 60 ml of fluid (20 ml of iothalamate sodium and 40 ml of saline [0.9% Na Cl] solution) through an 8-F Foley catheter secured within the vagina. The cranial and caudal limits of the urethra were defined as the narrow portion of the neck of the bladder and the external urethral orifice (which opens into the vagina), respectively **(Fig 1).** These radiographic landmarks were compared with the cranial and caudal ends of the pubis, as viewed on a lateral radiograph. The distance from the neck of the bladder to the cranial extent of the pubis and the distance from the caudal extent of the pubis to the external urethral orifice were measured on a line parallel to the main axis of the pubis. The urethral length was measured from the neck of the bladder to the external urethral orifice.

Necropsy—After euthanatization, necropsy was performed. Suture placement and positions of the urethra, bladder, and vagina were determined.

Table 1—Anatomic and urodynamic measurements (mean ± SD) before and after colposuspension in 12 female Beagles

Measurement	Before	After	*P* value
Leak-point pressure (cm H_2O)	120 ± 40.1	168.9 ± 39.5	0.003
MUCP (cm H_2O)	43.7 ± 24.8	19.3 ± 9.5	0.006
Bladder leak pressure (cm H_2O)	70.1 ± 25.9	58.6 ± 17.5	0.274
Functional profile length (cm)	6.39 ± 1.79	7.66 ± 2.46	0.051
Total profile length (cm)	6.78 ± 1.81	8.08 ± 2.20	0.043
Neck of the bladder to pubis (cm)	25.0 ± 13.3	53.0 ± 16.6	< 0.001
Pubis to external urethral orifice (mm)	29.8 ± 9.0	3.0 ± 6.1	< 0.001
Neck of the bladder to external urethral orifice (mm)	95.6 ± 14.1	98.4 ± 14.3	0.009
Urethra to MUP (%)*	66.0 ± 11.9	59.3 ± 12.7	0.203

*Distance from the proximal extent of the urethra to the point of maximal urethral pressure (MUP), divided by the functional profile length.
MUCP = Maximum urethral closure pressure.

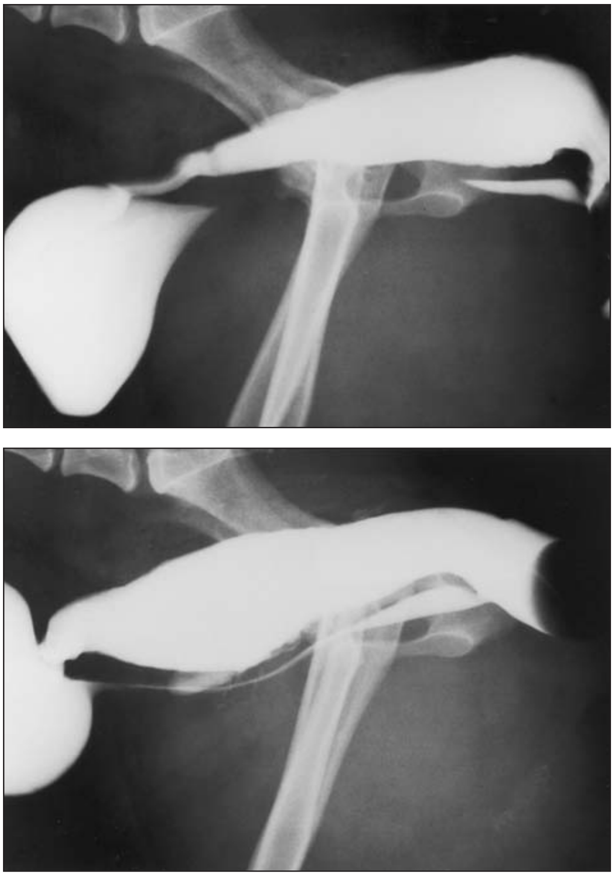

Figure 2—Contrast vaginourethrocystographic view of a female Beagle before (upper) and after (lower) colposuspension. Notice that after colposuspension the external urethral orifice was positioned cranially, compared with its position before colposuspension. The urethra and bladder have also been moved cranially into the abdomen. Contrast material ventral to the vagina likely leaked through vaginal suture holes.

Statistical analyses—Data were expressed as mean ± SD. Statistical comparisons of measurements made before and after colposuspension were performed by use of a paired *t*-test. Urodynamic data were compared by use of a *t*-test with that reported for clinically normal dogs.[10]

Results

Urodynamic studies—After colposuspension, LPP increased significantly, and MUCP decreased significantly **(Table 1).** Bladder leak pressure recorded after colposuspension was not different from values obtained before colposuspension. The functional profile length was increased after surgery. The location of the MUCP within the urethra was unchanged by surgery (Table 1). Urodynamic measurements from these anesthetized Beagles (MUCP, 43.7 cm H_2O; LPP, 120.2 cm H_2O) were lower than those reported for nonanesthetized clinically normal hound dogs (MUCP, 110.1 cm H_2O; LPP, 172.5 cm H_2O).

Contrast radiography—Colposuspension moved the entire urethra cranially **(Fig 2).** The neck of the bladder was situated in a more cranial abdominal position, and the external urethral orifice was moved cranially toward the pelvic cavity (Table 1). The distance form the neck of the bladder to the external urethral orifice was slightly increased, indicating that the urethra was longer. Urethral length was difficult to measure, because only the lateral view was used. The urethra was commonly tortuous and did not appear to be a straight tube. None of the urethras appeared to be kinked or obstructed in the area of the colposuspension sutures.

Necropsy—Colposuspension sutures consistently entered the vaginal lumen. Sutures within the vagina were 1.5 to 4 cm cranial to the external urethral orifice. Most sutures were 2 or 2.5 cm cranial to the external urethral orifice. The distance between the left and right sutures in the prepubic tendon was 1 to 1.5 cm. None of the colposuspension surgeries caused a compressive band around the urethra.

Discussion

Urinary incontinence develops in > 20% of spayed female dogs.[11] Incidence of incontinence exceeds 30% in spayed female dogs that weigh > 20 kg and is common in obese dogs. Seventy-five percent of incontinent dogs develop signs within 3 years of ovariohysterectomy, but incontinence may develop at any time before 12 years of age.[11,12] Nearly 100% of incontinent dogs are described by their owners as being incontinent during sleep or when recumbent. Most are incontinent daily, and approximately one third are incontinent once per week. Incontinence is associated with sphincter incompetence, but the mechanism has also been described as multifactorial.[13] In addition to sphincter incompetence, incontinence is also correlated with the neck of the bladder being positioned within the pelvic cavity and with short urethral lengths.[1,13,14] In contrast, dogs with normal urination may also have the neck of the bladder positioned within the pelvis.[15] Approximately two thirds of incontinent dogs respond to estrogen treatment, and three quarters[11] or more[16] respond to treatment with α-agonist drugs. Both medical treatments need to be given throughout life. The colposuspension technique that was adapted for dogs is similar to the Burch procedure commonly used in women.[8,17] Slightly > 50% of incontinent dogs are completely cured by colposuspension.[1,3] The degree and frequency of incontinence is reported as being substantially improved in an additional 40% of dogs, and surgery is not effective in 10%. Younger dogs (those < 8 years old) should have colposuspension as the first treatment in order to avoid life-long medical treatment.[3] Other dogs recommended for colposuspension are those that do not respond well to medical treatment or those whose owners are reluctant or not able to administer drugs regularly.[3]

This study sought to determine whether results of any preoperative test correlated with the expected clinical responses to colposuspension. Because only one-half of dogs with incontinence attributable to spaying respond favorably to colposuspension, a test that correlates with or predicts postoperative response would be useful. Colposuspension increased LPP in this study but did not increase MUCP or bladder leak pressure. The external urethral orifice, as measured by use of a retrograde vaginourethrocystogram, was moved cranially toward the pelvic cavity. Urination behavior in our research Beagles was difficult to document, because these dogs were housed in cages and were reluctant to void during observation. However, most of these anesthetized Beagles were obese; their mean MUCP (43.7 cm H_2O) was lower than that of conscious clinically normal dogs, and their mean LPP (120.2 cm H_2O) was lower than that of propofol-anesthetized normal dogs.[10] Colposuspension in the Beagles in our study caused LPP to increase from below reference range to within reference range, as reported for dogs anesthetized by administration of propofol. Although the baseline LPP values in our Beagles were measured during halothane anesthesia after thiopental induction, measurements obtained before and after colposuspension were obtained during a consistent plane of anesthesia. We detected neither an increase in MUCP nor a cranial movement of the MUCP after colposuspension, in contrast to results found in incontinent dogs.[4] The urodynamic and radiographic changes were most likely the result of the colposuspension, rather than the laparotomy. Sham-operated dogs were not included in our experimental or previous clinical studies,[1,2,4] in an effort to reduce the number of dogs that were used. Differences in UPP measurements between our study and those of others may be related to substantially different pressure measurement and anesthetic protocols.[18-24] The finding that the point of MUCP in our Beagles was not moved cranially may be attributed to the positioning of the colposuspension sutures to avoid creating a compressive band around the urethra.

Urethral pressure profilometry has been used to characterize incontinence attributable to spaying, before and after treatment.[2,4,25-28] Although techniques, including the use of anesthesia, vary among investigators, UPP is low in dogs with spay-induced incontinence,[2,18,19] increases in response to phenylpropanolamine treatment,[16] and decreases during anesthesia.[20] In an attempt to determine whether preoperative MUCP of incontinent dogs was predictive of continence after colposuspension, Holt reviewed preoperative UPP of cured and uncured dogs. Because there was no significant difference between the 58 cured dogs and the 46 uncured dogs, it was concluded that UPP was not a prognostic indicator.[2] There was an increase in MUCP in the UPP from a median of 4.5 cm H_2O before surgery for incontinence to 21.3 immediately after colposuspension in anesthetized dogs. There were also significant increases in functional profile length and distance between the neck of the bladder and the first negative respiratory peak and stressed spike.[4] Gregory felt that the postoperative UPP had a pronounced peak in the proximal one-third of the profile length.[4]

Urinary incontinence in women is usually induced by the stress of abruptly increased abdominal pressure during sudden movements, laughter, coughing, and heavy lifting. The most likely causes are sphincter incompetence and urethral hypermobility, with the latter being the most common mechanism for older women.[8] Treatment is based on cause; hypermobility is treated by use of a variety of surgical procedures that elevate or suspend and reposition the urethra to its premenopausal position.[8] Some of these procedures may be used in women with urethral hypermobility combined with sphincter dysfuction. Women with incontinence attributable to sphincter dysfunction are usually treated by use of injectable medications, pubovaginal slings, or, lastly, use of an artifical urinary sphincter.[8] Colposuspension as used in dogs was adapted from the Burch procedure used to treat women with urethral hypermobility.[17] In general, median success rate for the Burch procedure in women is > 80%.[8] This success rate is much greater than that reported for colposuspension in incontinent dogs, suggesting that hypermobility is not as important a component of incontinence in dogs as in women. The effect of suddenly increased abdominal pressure on continence has been evaluated in women who underwent suspension of the neck of the bladder for stress incontinence and experimentally in dogs and cats. The improvement in continence attributable to surgery is a result of pressure is applied to the abdominal side of the urethra when increased pressure occurs, thereby augmenting sphincter tone and increasing intraurethral pressure.[9,29,30] Despite successful surgical treatment by the Burch colposuspension and bladder-neck suspension procedures, changes in UPP measurements were not detected in women.[31]

The rationale for clinical improvement after colposuspension in incontinent female dogs is based on urethral lengthening and cranial movement of the neck of the bladder and proximal portion of the urethra.[1,3] Immediately after colposuspension in incontinent dogs, functional profile length was increased. The neck of the bladder was moved cranially away from the pelvic cavity, as revealed by vaginourethrocystography.[1] Holt theorized that the neck of the bladder and the proximal portion of the urethra are moved into the abdominal pressure zone such that any increase in abdominal pressure acts on the bladder, the neck of the bladder, and the proximal portion of the urethra simultaneously. The percentage by which the urethra was lengthened in our study was modest. Mean functional and total profile lengths were increased 19.9 and 19.2%, respectively, by surgery. Urethral length, as measured on a lateral radiographic view of the abdomen, was significantly increased by 3%. Cranial movement of the urethra, particularly by moving the caudal portion to a more pelvic location, would probably increase the impact of increased abdominal pressure on the urethra. It is interesting to speculate how the urethra is lengthened by sutures placed in the caudal end in order to place traction tension toward the cranial end. Movement of a full urinary bladder cranially into the dog's abdomen may provide traction for further lengthening of the urethra.

[a]Dual Energy X-ray Absorptioneter, DEXA model #QDR-1000W, Hologic Inc, Waltham, Mass.

[b]Edwards G, Department of Physiology and Pharmacology, College of Veterinary Medicine, University of Georgia, Athens, Ga: Personal communication, 2000.

[c]Janus System III (MC394) urodynamic system, Life-Tech Inc, Houston, Tex.

[d]Urethral pressure profile catheter (UPP-8D), Life-Tech Inc, Houston, Tex.

[e]Dual Lumen catheter (DLC-6D), Life-Tech Inc, Houston, Tex.

[f]Iothalamate sodium (Conray), Mallinckrodt, St Louis, Mo.

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