Laparoscopic-assisted cystopexy in dogs

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Objective—To develop a laparoscopic-assisted technique for cystopexy in dogs.

Animals—8 healthy male dogs, 7 healthy female dogs, and 3 client-owned dogs with retroflexion of the urinary bladder secondary to perineal herniation.

Procedures—Dogs were anesthetized, and positive pressure ventilation was provided. In the healthy male dogs, the serosal surface of the bladder was sutured to the abdominal wall. In the healthy female dogs, the serosa and muscular layer of the bladder were incised and sutured to the aponeurosis of the external and internal abdominal oblique muscles. Dogs were monitored daily for 30 days after surgery.

Results—All dogs recovered rapidly after surgery and voided normally. In the female dogs, results of urodynamic (leak point pressure and urethral pressure profilometry) and contrast radiographic studies performed 30 days after surgery were similar to results obtained before surgery. Cystopexy was successful in all 3 client-owned dogs, but 1 of these dogs was subsequently euthanatized because of leakage from a colopexy performed at the same time as the cystopexy.

Conclusions and Clinical Relevance—The laparoscopic-assisted cystopexy technique was quick, easy to perform, and not associated with urinary tract infection or abnormalities of urination. (*Am J Vet Res* 2002;63:1226–1231).

Cystopexy has been used for treatment of urinary incontinence in female dogs with pelvic bladder[1,2] and to prevent retroflexion of the urinary bladder in male dogs with perineal hernia.[3] Traditionally, a laparotomy has been required prior to cystopexy; however, use of a laparoscopic technique would potentially avoid some of the complications associated with laparotomy. The purpose of the study reported here was to develop a laparoscopic-assisted technique for cystopexy in dogs. In addition, results of this technique were evaluated in 3 privately owned male dogs with retroflexion of the urinary bladder secondary to perineal herniation.

Materials and Methods

Animals—The study protocol was approved by the University of Georgia Laboratory Animal Care and Use Committee. Eight healthy sexually intact male and 7 healthy sexually intact female dogs were used to develop laparoscopic-assisted techniques for cystopexy. Mean ± SD weight of the male dogs was 25.2 ± 3.57 kg (range, 20 to 30 kg); mean ± SD weight of the female dogs was 21.4 ± 3.85 kg (range, 17.4 to 28 kg). To reduce the number of dogs used for development of laparoscopic-assisted techniques, procedures described in the present report were performed during the same anesthetic episode that procedures used to develop laparoscopic-assisted techniques for incisional gastropexy, enterostomy tube placement, and jejunal biopsy were performed.[4,5] Before surgery, a CBC, serum biochemical profile, and urinalysis were performed on each dog. In addition, urodynamic studies (ie, measurement of residual volume, urethral pressure profilometry, and leak point pressure study) and retrograde vaginourethrography were performed before surgery in the female dogs.

Anesthesia—Dogs were premedicated with atropine (0.04 mg/kg, IM) and acepromazine (0.1 mg/kg, IM), and anesthesia was induced with thiopental sodium (12 mg/kg, IV) and maintained with halothane in oxygen. Hypothermia was reduced by placing dogs on recirculating warm-water blankets. Anesthetic depth was monitored by evaluating

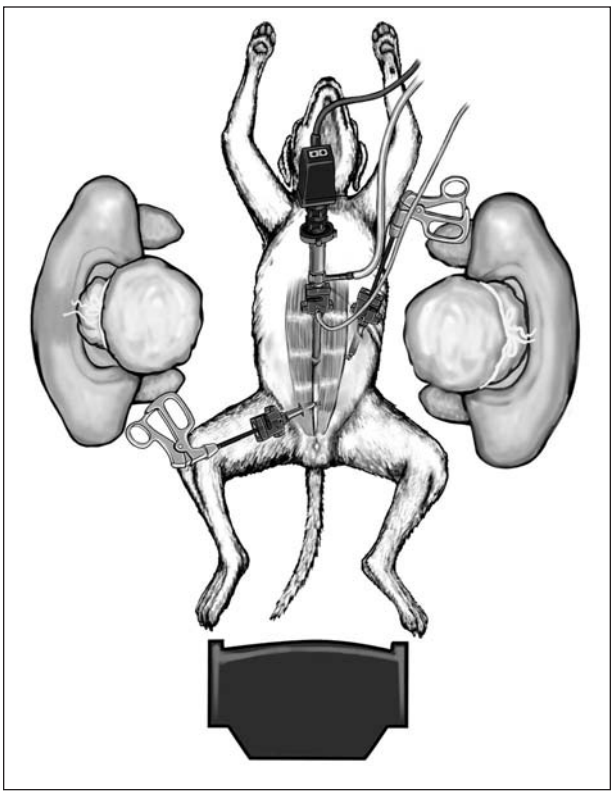

Figure 1—Aerial view of a method for laparoscopic assisted cystopexy in dogs. The primary surgeon is located on the patient's right side. Although less convenient for viewing the monitor, this position is better for incising and suturing a right-side cystopexy site. Trocar cannulas are placed for laparoscope (caudal to umbilicus) and Babcock tissue forceps, which are used for grasping and placing cranial traction on the urinary bladder.

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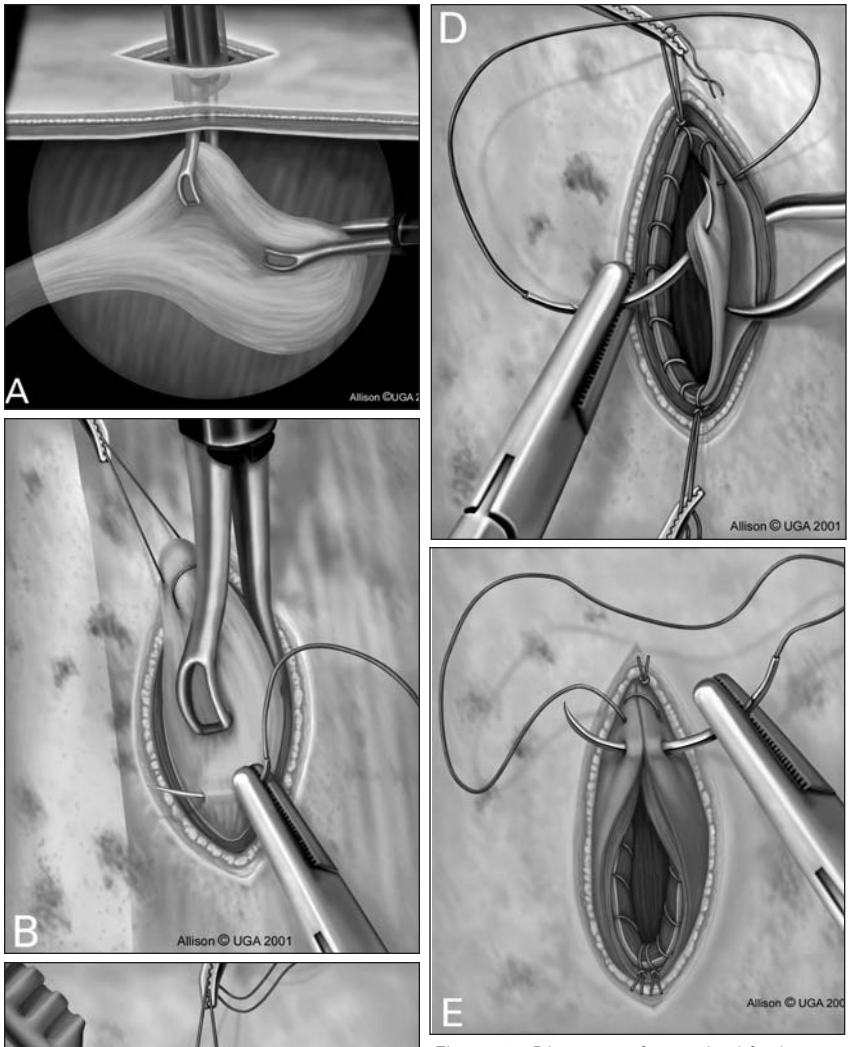

Figure 2—Diagrams of a method for laparoscopic-assisted incisional cystopexy in dogs. A—A laparoscopic Babcock forceps inserted through a trocar is used to grasp the bladder and apply cranial traction to position the ventral portion of the bladder against the selected cystopexy site. A longitudinal incision is made through the abdominal musculature, and a laparoscopic Babcock forceps inserted through this incision is used to elevate the bladder. This laparoscopic Babcock forceps may or may not be placed through a trocar depending on the proximity of the bladder to the abdominal wall. B—Cruciate traction sutures are placed 2.5 to 3 cm apart in the bladder. C—The serosa and muscular layers of the bladder are incised between the traction sutures, avoiding entering the lumen of the bladder. D—A simple continuous suture of 2-0 or 3-0 polydioxanone is placed to appose the aponeurosis of the external and internal abdominal oblique muscles and deep layers of the rectus abdominis muscle to the serosa and incised muscle of the bladder wall. Care is taken to avoid placing suture material in the bladder lumen. The initial cruciate sutures are removed. E—The medial and lateral sides of the combined aponeurosis of the external and internal abdominal oblique muscles and the superficial layers of the rectus abdominus muscle are closed in a simple continuous fashion. Remaining closure is routine.

reflexes and measuring heart rate and indirect blood pressure every 5 minutes. Lactated Ringer's solution was given IV at a rate of 10 ml/kg/h. During laparoscopy and abdominal insufflation with carbon dioxide, positive pressure ventilation was provided (12 breaths/min; approx tidal volume, 12 mL/kg; peak inspiratory pressure, < 25 cm H_2O).[6] Butorphanol (0.15 mg/kg, IV) was administered at the end of surgery and again 12 hours later. Female dogs also received carprofen (3 mg/kg, PO, q 12 h for 7 days) and enrofloxacin (5 mg/kg, PO, q 24 h for 5 days). Male dogs were given ampicillin (20 mg/kg, PO, q 12 h for 5 days).

Surgery—Dogs were placed in dorsal recumbency, and the surgery table was tilted so the dog's head was lowered slightly (mild Trendelenburg position). Sites for placement of the trocar cannulae were selected to provide good viewing via the camera[a] and appropriate grasping of the bladder (**Fig 1**). One cannula (10- to 12-mm diameter) was placed on the ventral midline, 2 to 3 cm caudal to the umbilicus, using the open (Hasson) technique.[7] During placement of this cannula, retraction sutures of size-0 polydioxanone were placed on either side of the linea alba incision and were then used to maintain a tight seal around the cannula during abdominal insufflation. The peritoneal cavity was distended with carbon dioxide with an insufflator,[b] and a 0° 10-mm laparoscope[c] was placed through the cannula. The laparoscope was connected to a 3-chip camera and xenon light source.[d]

In the male dogs, a second trocar cannula was placed lateral to the right rectus abdominis muscle in the mid-abdominal area. A 10-mm laparoscopic Babcock forceps[e] was inserted through this cannula and used to grasp the bladder and pull it cranially and along the right ventral aspect of the abdominal wall. A 2.5-cm-long incision was then made through the skin and subcutaneous tissues immediately overlying the bladder. Three cruciate sutures of 2-0 polypropylene were placed through the abdominal muscular wall and into the bladder and cranial portion of the urethra. The subcutaneous tissues and skin were individually closed.

In the female dogs, laparoscopic-assisted incisional cystopexy was performed. For this procedure, A 10- or 12-mm laparoscopic trocar for a 10-mm laparoscope was placed on the midline, 2 cm caudal to the umbilicus. A second trocar was placed lateral to the first trocar and just lateral to the rectus abdominus. This second trocar was used for a 10-mm Babcock forceps, which was used to grasp and pull the

cranial portion of the bladder cranially. A cystopexy site on the inside of the abdominal wall was selected on the right side of the abdomen, just medial to the caudal superficial epigastric vessels, and a 3-cm-long incision was made longitudinally through the abdominal muscles. A Babcock forceps was inserted through this incision and used to grasp the midportion of the bladder and elevate it to the level of the incision (**Fig 2A**). Two traction sutures of 2-0 polydioxanone were placed in the bladder 3cm apart (**Fig 2B**). A 2.5- to 3-cm-long incision was then made in a cranial-to-caudal direction through the serosa and superficial layers of bladder wall muscle (**Fig 2C**). A simple continuous suture of 2-0 polydioxanone was used to appose the medial aspect of the seromuscular incision in the bladder to the medial aspect of the incision in the aponeurosis of the external and internal abdominal oblique muscles, and a parallel continuous suture was placed to appose the lateral aspects (**Fig 2D**). The incision in the abdominal musculature was then closed with size-0 polydioxanone in a continuous patter (**Fig 2E**). Two layers of subcutaneous sutures and interrupted skin sutures were then placed. Following completion of the incisional cystopexy, the bladder was examined laparoscopically (**Fig 3**) and cystoscopically.

Postoperative care and monitoring—Dogs were monitored daily for at least 30 days after laparoscopy. Complete blood counts were performed 3 and 7 days after surgery in the 8 male dogs, and dogs were euthanatized at least 30 days later. A necropsy was performed within 1 hour after dogs were necropsied, and samples were collected from the 8 male dogs for mechanical testing of the strength of the adhesion site. Urodynamic studies and retrograde vaginourethrography were repeated 30 days after surgery in the 7 female dogs, and urine samples were submitted for urinalysis and aerobic bacterial culture. Six of the female dogs were then euthanatized, and a necropsy was performed. The seventh female dog, which was clinically normal, was adopted by a research technician. The dog underwent ovariohysterectomy prior to adoption, and the cystopexy site was examined grossly at this time.

Mechanical testing—In the 8 male dogs, the cystopexy site was removed in such a way that portions of the bladder and apposing abdominal wall remained, and these portions were cryofixed to custom-made clamps. Tissue at the site of fixation to the cryoclamps was 1.5 to 6 cm wide. The clamps were placed in the testing machine[f] 5 to 10 cm apart, with the cystopexy site centered between the fixation points. Although the cryoclamps were cooled with dry ice, the cystopexy site was maintained at approximately 21 C with a warm-water recirculating system. The cystopexy was loaded in tension to failure. Maximum load was 448 N with a sensitivity of ± 1 N. Displacement velocity was 2.54 mm/min. A graph of displacement versus load was recorded, and the tissue was videotaped during loading. Because the videorecorder did not permit viewing of the cystopexy from all sides, displacement data were used to assess deformation of the cystopexy.

Histologic evaluation—After mechanical testing in the 8 male dogs and at the time of necropsy in the 6 female dogs, tissue from the cystopexy site was placed in neutral-buffered 10% formalin. Full-thickness sections of the cystopexy site were routinely processed and embedded in paraffin. The suture material was removed, and replicate sections were cut and stained with H&E or Masson trichrome stain. Sections were examined histologically, and adhesion sites were subjectively evaluated for amount and maturity of connective tissue (granulation tissue vs dense collagenous tissue), the amount of collagen, and the degree of inflammation associated with or not associated with sutures.

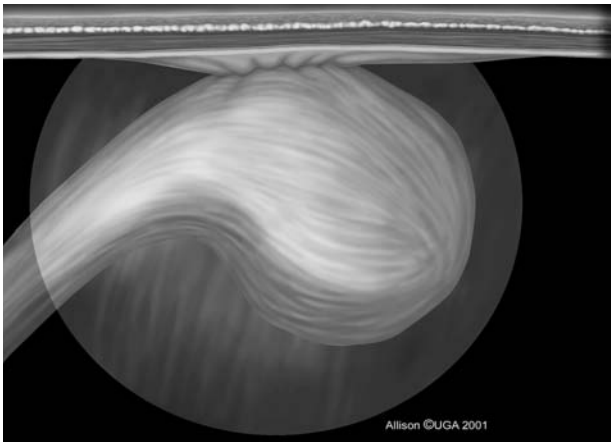

Figure 3—Diagram of the laparoscopic appearance of the cystopexy site following laparoscopic-assisted cystopexy in a dog. The bladder should be examined to ensure that there is no evidence of twisting of the outflow tract.

Urodynamic and contrast radiographic studies—Urodynamic studies[8] were performed on the 7 female dogs before and 30 days after surgery. Food was withheld prior to urodynamic studies, and ampicillin was administered. Urethral pressure profilometry was performed with an 8-F urethral catheter[g] and computer-based urodynamic system.[h] The dog was taken outside to void, and then returned to the laboratory. The bladder was catheterized with a 6-F catheter,[i] and residual volume was measured. The dog was then anesthetized with propofol (8 mg/kg, IV, then 0.4 mg/kg/min, IV, to effect). Leak point pressure measurements were obtained. Radiography was then performed to determine bladder position,[9] and positive-contrast cystography was performed by injecting iothalamate sodium[j] diluted 1:5 with saline (0.9% NaCl) solution at a rate of 11 ml/kg while the dog was lying on its left side. Vaginourethrography was performed by injecting an additional 20 ml of iothalamate with 40 ml of saline solution through an 8-F Foley catheter secured in the vestibule. The cranial and caudal ends of the urethra were defined as the narrow portion of the bladder neck and the urethral meatus in the vestibule, respectively.[9] Radiographic landmarks were compared with the cranial and caudal ends of the pubis, as viewed on the lateral radiographic projection. The distance from the bladder neck to the cranial extent of the pubis and the distance from the caudal extent of the pubis to the urethral meatus were measured on a line parallel to the main axis of the pubis. The urethral length was measured from the bladder neck to the urethral meatus.

Statistical analyses—Results of urodynamic and contrast radiographic studies obtained before surgery were compared with results obtained after surgery with paired *t* tests. Values of $P \leq 0.05$ were considered significant.

Results

All dogs recovered rapidly from surgery, and none had any signs of illness. Voiding was normal for all dogs after cystopexy. Results of CBCs performed 3 days after surgery were reflective of a mild inflammatory response in 4 of the 8 male dogs. Results were unchanged in the other 4 male dogs. The inflammatory response consisted of a mature neutrophilia with no evidence of immature neutrophils. Mean WBC and segmented neutrophil counts increased significantly from 9,362 and 5,177 cells/µl, respectively, to 16,700 and 12,346 cells/µl. The highest total WBC count 3

days after surgery was 23,900 cells/µl. Results of CBC performed 7 days after surgery were normal.

At necropsy, the bladder and proximal portion of the urethra were adhered to the abdominal wall in all dogs. In all 8 male dogs, the tissue failed at the cystopexy site during mechanical testing, and tissue distal to the cystopexy site remained attached to the cryoclamps. Therefore, load data reflected the strength behavior of the tissue at the cystopexy site. Mean ± SD ultimate load was 89.8 ± 77.9 N (range, 28 to 214 N; median, 58.2 N).

When examined histologically, samples from 7 of the 8 male dogs had evidence of adhesion of the bladder to the abdominal musculature. In the eighth dog, although an adhesion was not evident histologically, an adhesion was evident prior to mechanical testing. Adhesions consisted of fibrous tissue with moderate to abundant collagen. Two dogs had evidence of lymphoplasmacytic inflammation, and another had purulent inflammation. A mild histiocytic or plasmacytic infiltration was evident surrounding the sutures in 6 of 8 dogs.

Urinalysis and bacterial culture of urine samples 1 month after cystopexy did not provide any evidence of urinary tract infection in the female dogs. All dogs had residual volumes < 20 ml 1 month after cystopexy, and results of urodynamic and contrast radiographic studies performed 1 month after surgery were not significantly different from results obtained prior to surgery. Cystography did not reveal any clinically important deviations or kinks in the bladder neck or urethra.

In the 6 female dogs that underwent necropsy, there was a strong adhesion between the urinary bladder and abdominal wall. Mean length of the cystopexy site was 2.3 cm (range, 2 to 3 cm). Subjectively, cystopexy adhesions appeared to be more consistent and stronger than those seen in the male dogs. Histologically, the musculature of the body wall was firmly adhered to the tunica muscularis of the bladder. Dense collagenous fibrous tissue extended through the incision in the abdominal musculature. Within this fibrous tissue, multiple clear spaces, presumably suture sites, were surrounded by mild granulomatous inflammation and a thin fibrous rim. There was mild diffuse subepithelial infiltration of lymphocytes, plasma cells, and eosinophils in the bladder. Although no suture material was seen in the bladder lumen and the mucosa appeared to be intact in all dogs, suture material was seen close to the lumen in some dogs. In the seventh dog, the cystopexy site appeared at the time of ovariohysterectomy to be grossly similar to the sites in the other female dogs.

Clinical cases—Laparoscopic-assisted cystopexy was performed in 3 client-owned dogs. All 3 dogs had retroflexion of the bladder secondary to perineal herniation. The first dog was a 10-year-old male Collie that had been referred because of recurrence of bilateral perineal hernias and retroflexion of the urinary bladder. Standard bilateral herniorrhaphy with rotation of the internal obturator muscles was performed, and the dog was castrated. Unfortunately, the repair had failed when examined 2.5 months later. The client requested that no additional perineal surgery be performed, but did consent to laparoscopy. Three 10-mm trocars were used, with 1 placed on the ventral midline for insertion of the laparoscope and the others used for insertion of Babcock forceps. There was a tremendous amount of omentum and adhesions in the perineal area where the descending colon and urinary bladder were retroflexed. Dissection and retraction of the bladder were difficult, requiring inflation of the bladder via a urethral catheter and rectal manipulation. The colon and bladder were sutured to the left and right sides of the abdominal wall, respectively. Because of the thickness of the abdominal muscular wall and the dog's obesity, size-0 polypropylene suture material was used. Considerable dissection of fat from the peritoneal surfaces was required before the serosal surfaces of the bladder and colon could be apposed to the abdominal wall. Recovery after surgery was slow. The dog would not void urine on its own, and some urine leaked from the abdominal incision when the bladder was expressed. A urethral catheter was placed and leakage resolved. Paracentesis 11 days after surgery revealed bacterial peritonitis. The abdomen was explored and leakage was found at the colopexy site but not at the cystopexy site. The dog was euthanatized.

The second dog was a 9-year-old castrated male Yorkshire Terrier. The dog had intermittent urinary obstruction and repeated attempts to void. Bilateral perineal hernia repair had been performed 7 months previously. Ten days prior to referral, the dog began to dribble urine and was unable to develop a urine stream even when straining to void. Positive-contrast cystourethrography (**Fig 4**) demonstrated obstruction at the vesicourethral junction when pressure was applied to the caudal portion of the abdomen. Laparoscopic-assisted incisional cystopexy was performed. A 5-mm trocar was placed on the ventral midline for a 5-mm laparoscope. A second 5-mm trocar was used for a 5-mm grasper, which was used to pull the bladder cranially. A 2.5-cm-long longitudinal incision was made through the right rectus abdominis muscle, and incisional cystopexy was performed, with parallel continuous suture patterns of 3-0 polydioxanone used to appose the seromuscular layer of the bladder to the aponeurosis of the external and internal abdominal oblique muscles. Left-side perineal hernia repair with rotation of the internal obturator muscle was also performed. Clinical signs resolved, and the dog urinated normally within 2 days. Ten months after cystopexy, urine voiding and results of contrast radiography were normal.

The third dog was an 8-year-old male Rottweiler that was referred because of bilateral perineal herniation. Retroflexion of the urinary bladder was confirmed with contrast radiography. Standard bilateral herniorrhaphy with rotation of the internal obturator muscles and laparoscopic-assisted incisional cystopexy were performed. Only 2 trocars, a 10-mm trocar for the laparoscope and a second 10-mm trocar for Babcock forceps, were used, and the incision in the right rectus abdominis muscle was 6 cm long. The bladder was friable, and sutures easily tore through the bladder wall. Two rows of continuous sutures of size-0 polydiox-

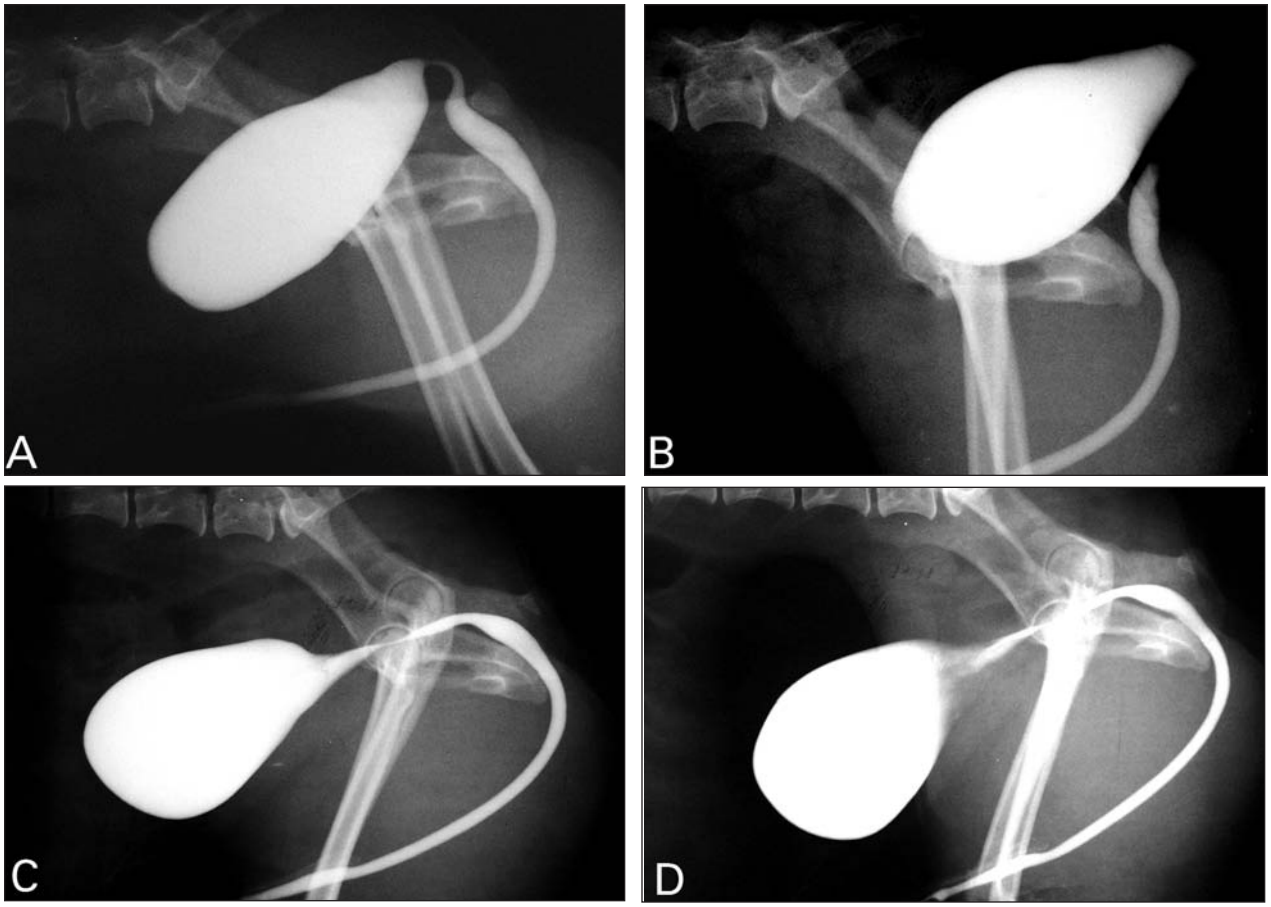

Figure 4—Lateral positive-contrast cystourethrographic views of a 9-year-old Yorkshire Terrier with a history of acute urinary obstruction and repeated attempts to urinate. A—Prior to surgery, the bladder was located within the pelvis, and the urethra appeared to be kinked or obstructed. B—When pressure was applied to the caudal portion of the abdomen prior to surgery, the urethra became sufficiently kinked at the vesicourethral junction to obstruct flow. C—Ten months after laparoscopic-assisted incisional cystopexy, the bladder appeared to be positioned more normally. D—Application of pressure to the caudal portion of the abdomen 10 months after surgery did not result in caudal movement of the bladder or urethral kinking.

anone were placed between the seromuscular layer of the bladder and the aponeurosis of the external and internal abdominal oblique muscles, and the dog was castrated. During a telephone interview 9 months after surgery, the owner indicated that the dog had had no recurrences and was clinically normal.

Discussion

Results of the present study suggest that laparoscopic-assisted cystopexy is an acceptable alternative to cystopexy performed during a laparotomy. Although the initial laparoscopic-assisted cystopexy technique, which involved placing sutures through the abdominal wall, appeared to produce a good adhesion, it was difficult to ensure that the bladder lumen was not penetrated. Urine leakage in the first clinical case may have been related to urine retention and the large needle size required to penetrate the abdominal wall. Laparoscopic-assisted incisional cystopexy was the preferred technique, as the skin incision was the same length as that required for the first technique, suturing could be done easily and directly monitored, and the bladder muscles were apposed to rectus abdominis muscle. This is similar to the muscle apposition concept used to produce a secure gastropexy.[4,10-12] The site of the cystopexy can be extended into the proximal portion of the urethra for female dogs with pelvic bladder or placed more cranially on the bladder in dogs with bladder retroflexion secondary to perineal herniation. Laparoscopy also permits viewing of the completed cystopexy to confirm appropriate cranial traction has been placed on the bladder without twisting of the outflow tract or urethral obstruction. A 30^0 laparoscope permits evaluation of the lateral side of the outflow tract and urethra, even when used from a midline trocar.

Cystopexy did not appear to adversely affect urinary function, and all dogs urinated normally. Also, there was no evidence of an increased likelihood for urinary tract infection. Cystourethropexy has been used for treatment of incontinence in spayed female dogs.[1,2] In 1 study,[1] for instance, 73 of 100 dogs that underwent urethropexy had an excellent outcome (complete cure without dribbling), but 21 dogs had complications, including increased frequency of urination, dysuria, anuria, and urinary tract infection. In a smaller study[1] of 10 dogs, only 2 dogs had complete urinary control, and 2 others were improved. Cystopexy has been found to be of limited value as the sole procedure for retroflexion of the bladder in

dogs with perineal hernia.[3] We have used cystourethropexy in 1 female dog with persistent, resistant urinary tract infection. It was presumed that partial retroflexion of the bladder, as determined by means of contrast cystography, prevented complete bladder emptying. Following cystopexy and appropriate antimicrobial treatment, the urinary tract infection was controlled. Another method to provide cranial movement of the bladder in male dogs secures the vasa deferentes cranially to the abdominal wall for treatment of urethral sphincter mechanism incompetence[13] and perineal herniation with retroflexion of the bladder and prostate.[14]

Laparoscopic-assisted colopexy was performed in addition to laparoscopic-assisted cystopexy in the first clinical case described in the present report. Complications developed as a result of leakage from needle holes in the colon. This may have been associated with the size of the needle used, the fact that the dog was recumbent much of the time after surgery, or the fact that the dog was reluctant to defecate after surgery. In a small series of cases,[3] colopexy was found to have limited value as a sole treatment for perineal hernia; however, we believe it may have some benefit in dogs with recurrent rectal prolapse. In contrast to the technique used in the first clinical patient, we would now perform laparoscopic-assisted incisional colopexy in a similar fashion as was described for laparoscopic-assisted incisional cystopexy.

[a]Tricam camera and image processor, Karl Storz Endoscopy American, Culver City, Calif.
[b]Electronic Endoflator, Karl Storz Endoscopy American, Culver City, Calif.
[c]Olympus 0° 10-mm 29-cm telescope, Olympus, Tuttlinger, Germany.
[d]Zenon nova, Karl Storz Endoscopy American, Culver City, Calif.
[f]Babcock forceps, Ethicon-Endo, Cincinnati, Ohio.
[f]Tenslon analyzer, Model 4201, Instron Corp, Canton, Mass.
[g]Urethral pressure profile catheter (UPP-8D), Life-Tech Inc, Houston, Tex.
[h]Janus System III (MC394) urodynamic system, Life-Tech Inc, Houston, Tex.
[i]Dual-lumen catheter (DLC-6D), Life-Tech Inc, Houston, Tex.
[j]Conray 400, Mallinckrodt Inc, St Louis, Mo.

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