Case Report Rapport de cas

Laparoscopic peritoneopericardial herniorrhaphy in 2 dogs

Valery F. Scharf, Mark Iannettoni, Carlos Anciano

Abstract — Two peritoneopericardial hernias (PPDH) repaired laparoscopically are reported. Both PPDHs were approached with the dog in dorsal recumbency. Herniated organs (gallbladder and 2 liver lobes in Case 1 and omental fat in Case 2) were dissected and reduced. Hernias were closed in a 2-layer horizontal mattress pattern using 2-0 polyester (Case 1), and in a single-layer simple continuous pattern using 0 barbed polyglyconate (Case 2). Reduction and herniorrhaphy were achieved without conversion. Moderate to severe systemic hypotension was observed in both dogs which responded rapidly to reducing abdominal insufflation. Ten- and 7-month follow-up confirmed good clinical outcome in both dogs.

Résumé — Herniorraphie péritonéo-péricardique laparoscopique chez deux chiens. Deux hernies péritonéo-péricardiques (PPDH) réparées par laparoscopie sont rapportées. Les deux PPDHs ont été réalisées avec le chien en décubitus dorsal. Les organes herniés (vésicule biliaire et deux lobes hépatiques dans le cas 1 et graisse épiploïque dans le cas 2) ont été disséqués et réduits. Les hernies ont été fermées avec un patron de suture matelas horizontal à deux couches en utilisant du polyester 2-0 (cas 1) et avec un modèle de suture continu simple à une seule couche en utilisant du polyglyconate barbelé 0 (cas 2). La réduction et l'herniorraphie ont été réalisées sans conversion. Une hypotension systémique modérée à sévère a été observée chez les deux chiens qui ont répondu rapidement à la réduction de l'insufflation abdominale. Un suivi de dix et sept mois a confirmé de bons résultats cliniques chez les deux chiens.

(Traduit par Dr Serge Messier)

Can Vet J 2022;63:947–952

Peritoneopericardial hernia (PPDH) is an uncommon form of congenital diaphragmatic hernia in which separation of peritoneal and pericardial cavities is incomplete, allowing abdominal organs to herniate into the pericardium (1–5). The most commonly herniated organs include liver, gallbladder, and small intestines, although herniation of omentum, stomach, spleen, and large intestine are also reported (1–3). Most dogs with PPDH (64 to 76%) have associated clinical signs. Clinical signs include gastrointestinal signs (vomiting, diarrhea, hyporexia, or anorexia), respiratory signs (cough, tachypnea, or dyspnea), and exercise intolerance or collapse (1–3).

Repair of PPDH in dogs is performed *via* a midline celiotomy with extension to a caudal median sternotomy as needed to access herniated organs; although approaching the hernia *via* a median sternotomy alone is also reported (1–3). If possible, penetration of the pleural space is avoided, minimizing the need for evacuation of the pleural cavity. Post-operative complications have been reported in 11 to 48% of dogs and include: pneumothorax, cardiac arrhythmias, pneumopericardium, pneumothorax, pericardial steatitis, gastrointestinal signs, and obstructive portal hypertension (1–3).

Minimally invasive surgery has been associated with decreased postoperative pain and pulmonary dysfunction in humans and decreased postoperative pain and wound complications and improved postoperative activity in dogs (6–8). To the authors' knowledge, laparoscopic repair of PPDH has not been reported in the dog. The objective of this report is to describe the successful laparoscopic herniorrhaphy of PPDH in 2 dogs, and to describe the management of specific intraoperative complications to improve the feasibility and safety of this novel approach.

North Carolina State University College of Veterinary Medicine Department of Clinical Sciences, Raleigh, North Carolina, USA (Scharf); East Carolina University, Greensville, North Carolina, USA (Iannettoni, Anciano).

Address all correspondence to Dr. Valery F. Scharf; email: vfscharf@ncsu.edu

The corresponding author is a paid consultant for Johnson & Johnson Medical Devices which produces products (vessel sealing device, suture) used in the described procedures. Case 1 was presented at the Eastern Cardiothoracic Surgical Society 57th Annual Meeting in Naples, Florida in October 2019.

Use of this article is limited to a single copy for personal study. Anyone interested in obtaining reprints should contact the CVMA office (hbroughton@cvma-acmv.org) for additional copies or permission to use this material elsewhere.

Case descriptions

Case 1

Clinical history and initial diagnostic tests. A 7-month-old intact male golden retriever was presented for evaluation of a

previously diagnosed peritoneopericardial hernia. The dog was first presented to the referring veterinarian for evaluation of nasal discharge and a cough. Thoracic radiographs at that time revealed increased soft tissue opacity in the caudoventral thorax suspicious of a diaphragmatic hernia. Computed tomography (CT) at another referral institution confirmed a PPDH with herniation of the right medial and left medial hepatic lobes and gallbladder. A complete blood (cell) count (CBC) and chemistry prolife performed at that time revealed a mild non-regenerative anemia (hematocrit 33%, reticulocytes 7.6 K/μL), but results were otherwise unremarkable. Nasal discharge and cough resolved within 2 wk with no treatment, and on admission to our institution 1 mo after initial presentation to the referring veterinarian, the dog had no clinical signs. Physical examination was unremarkable apart from an ~1-cm reducible umbilical hernia. Packed cell volume and total solids were within normal limits. Pre-operative focal ultrasound of the hepatobiliary system confirmed persistent herniation of the right and left medial liver lobes and gallbladder.

Surgical technique. The dog was premedicated with methadone (0.3 mg/kg, IM) and dexmedetomidine (2.0 μg/kg, IM), and induced with propofol (1.0 mg/kg IV) and ketamine (0.5 mg/kg). Anesthesia was maintained with isoflurane and a continuous rate infusion (CRI) of dexmedetomidine (0.5 μg/kg per hour), lidocaine (50 μg/kg per minute), and ketamine (30 μg/kg per minute). The dog also received maropitant (1.0 mg/kg, IV) and ondansetron (0.3 mg/kg, IV) at induction, and cefazolin (22 mg/kg, IV) was administered at induction and repeated every 90 min. Following induction, the dog was positioned in dorsal recumbency in reverse Trendelenburg positioning. Local nerve blocks (bilateral quadratus lomborum and caudal intercostal) were performed using 100 mg ropivacaine. A single incision laparoscopic port (SILS port; Medtronic, Minneapolis, Minnesota, USA) was placed just caudal to the umbilical hernia. Two 5-mm and one 12-mm cannulas were introduced through the single incision port, and abdominal insufflation was initiated at 6 mmHg. A 10-mm 30° laparoscope (Karl Storz Veterinary Endoscopy, Goleta, California, USA) was placed through the single incision port, and an additional left paramedian 10-mm cannula (Kii Fios First Entry; Applied Medical, Rancho Santa Margarita, California, USA) was placed. Both medial liver lobes, the gallbladder, and omental fat were observed passing through the PPDH into the pericardial space (Figure 1 A). An ultrasonic vessel sealing device (UVSD) (Harmonic Ace Shears, Ethicon, Somerville, New Jersey, USA) was used to dissect adhesions between omental fat and the hernia edges. Omental fat was reduced using the UVSD and laparoscopic atraumatic grasping forceps (Karl Storz Veterinary Endoscopy). No adhesions between the liver or gallbladder and the pericardial or epicardial surfaces were observed, and liver and gallbladder were reduced using a laparoscopic blunt probe. Pericardioscopy confirmed no abnormalities or hemorrhage within the pericardium (Figure 1 B). Adhesions between the liver and the dorsal aspect of the hernia were dissected using the UVSD (Figures 1 C, D). Following reduction, the dog developed significant systemic hypotension; abdominal insufflation pressure was reduced from 6 mmHg to 3 mmHg and a CRI of norepinephrine (0.15 μg/kg per minute) was initiated. Hypotension persisted, at which time insufflation was discontinued and systemic blood pressure improved. Following return of normotension, insufflation was returned to 3 mmHg and norepinephrine discontinued for the remainder of the procedure.

With insufflation continued at 3 mmHg, the diaphragmatic defect was closed using a suture assist device (Endo Stitch; Medtronic) to place horizontal mattress sutures with 2-0 polyester (Surgidac; Medtronic) (Figure 1 E). A second layer of horizontal mattress sutures was then placed with 2-0 polyester using an automated fastener (COR-KNOT DEVICE; LSI Solutions, Victor, New York, USA) to secure the knots. An 8.3 Fr 40-cm fenestrated pericardiocentesis catheter (Lock Pericardiocentesis Set; Cook Medical, Bloomington, Indiana, USA) was inserted through the single incision port and through the sutured diaphragmatic defect to evacuate the pericardial space (Figure 1 F). Suction was applied to the catheter as insufflation was discontinued until negative pressure was achieved, and the catheter was withdrawn. Both port sites were closed routinely with repair of the umbilical hernia. Bupivacaine liposome injectable suspension (138 mg) was infiltrated into the tissue surrounding both port sites prior to closure.

The dog recovered uneventfully from anesthesia and received methadone (0.2 mg/kg, IV), carprofen (2.2 mg/kg, SC), and trazodone (4 mg/kg, PO) post-operatively while in hospital and was discharged 1 d after surgery with carprofen (2.0 mg/kg, PO) and trazodone. One day following discharge, the dog was re-presented for evaluation of the incision due to complaints of pruritis and difficulty restricting activity. The incision appeared within normal limits, and diphenhydramine (2 mg/kg, PO, q8h) was recommended and the trazodone dose increased to 5 mg/kg, PO, q8h. The dog was re-evaluated at 2.5 wk after surgery and was doing well with no complications reported. A follow-up telephone call with the owners at 10 mo after surgery confirmed that the dog was doing well with no clinical signs related to the hernia.

Case 2

Clinical history and initial diagnostic tests. A 17-month-old neutered male boxer dog was presented for evaluation of a presumed intrapericardial cyst. The dog was first presented to the referring veterinarian 4 mo earlier for evaluation following a syncopal episode, at which time the dog was prescribed sotalol (40 mg, PO, q12h) and referred to a cardiologist for further evaluation. Echocardiogram performed 1 mo later revealed a large intrapericardial cyst adjacent to the right aspect of the apex of the heart and deforming the posterior wall of the left ventricle; no pericardial effusion was observed at that time, and the sotalol was discontinued. On admission for evaluation of surgical correction of the intrapericardial cyst, the dog had not been observed to have any additional syncopal episodes. A history of conjunctivitis, otitis externa, contact dermatitis, and regurgitation were reported. Pre-operative CBC and chemistry panel were unremarkable. A repeated echocardiogram revealed a 7 × 6 cm mass adjacent to the caudal left ventricular wall extending from the apical region to just ventral to the caudal

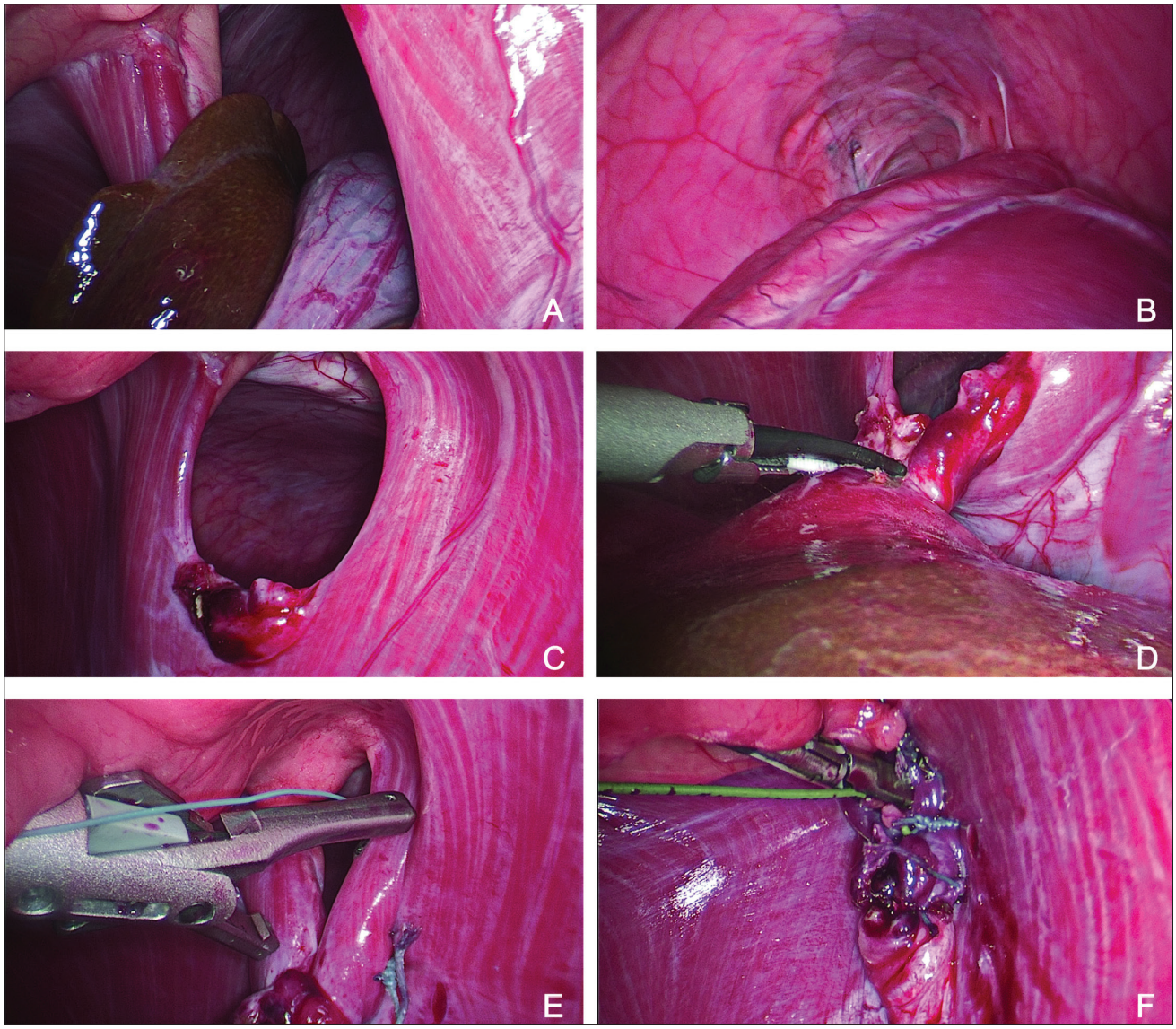

Figure 1. Laparoscopic repair of PPDH in Case 1. A – Right medial liver lobe and gallbladder are herniated through diaphragmatic defect. B – Intrapericardial view of the ventral surface of the epicardium. C – The PPDH defect following reduction of hernia contents. D – Debridement of hepatic adhesions to the dorsal hernia using a vessel sealing device. E – Closure of the PPDH with horizontal mattress sutures using a suture-assist device. F – Insertion of guidewire to guide placement of pericardial catheter to suction CO_2 from pericardial space.

vena cava. A preoperative CT was performed to evaluate the cyst and revealed a 5.5 × 8.0 × 6.0 cm fluid-attenuating well-marginated structure within the right caudolateral pericardial sac in close association with the right ventricle, causing moderate compression and dorsal elevation of the thoracic caudal *vena cava* and a mild leftward mediastinal shift (Figure 2). In addition, a large volume of fat was observed within the pericardial sac with a discrete communication with the abdominal falciform fat through a small ventral defect in the diaphragm, consistent with a PPDH. An aberrant and retro-esophageal right subclavian artery was also observed causing mild focal compression of the esophagus. Following discussion with the owners, a decision was made to attempt laparoscopic herniorrhaphy and thoracoscopic intrapericardial cyst resection.

Surgical technique. The dog was managed anesthetically in a similar manner to Case 1, with hydromorphone (0.05 mg/kg, IV) given as premedication instead of methadone and the addition of a fentanyl CRI (0.1 µg/kg per minute). Bilateral intercostal and *transversus abdominis* plane blocks were performed using 80 mg of bupivacaine. The dog was positioned and approached in the same manner as in Case 1, with the addition of a third 5-mm cannula (Karl Storz Endoscopy), approximately 5 cm to the right of midline and 7 cm cranial to the umbilicus. Three 5-mm cannulas were inserted through the single incision port to accommodate a 5-mm 30° endoscope (Karl Storz Endoscopy). Initial abdominal insufflation pressure was set at 8 mmHg. Laparoscopic exploration confirmed a large amount of omental and falciform fat herniated through the PPDH; both

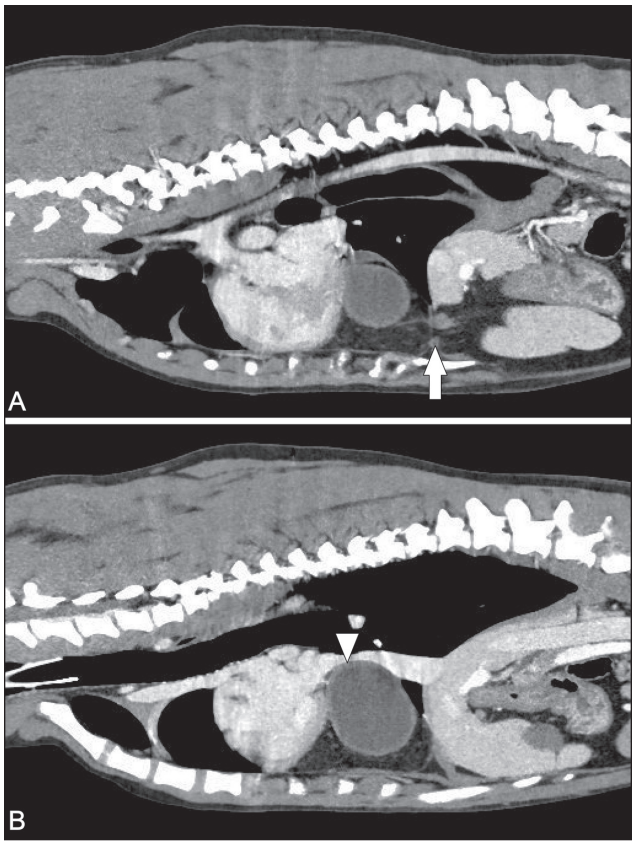

Figure 2. Sagittal CT image of PPDH and intrapericardial cyst in Case 2. A – Herniation of omental fat into the pericardium through the PPDH at the ventral aspect of the diaphragm is indicated by the white arrow. B – Compression of the caudal *vena cava* by the intrapericardial cyst is indicated by the white arrowhead.

were reduced using the UVSD and atraumatic forceps until the remaining herniated omentum was under too much tension to be further reduced and was transected at the level of the hernia using the UVSD. Pericardioscopy was performed through the hernia to confirm the location of the intrapericardial cyst at the caudodorsal aspect of the heart (Figure 3 A). Similar to Case 1, the dog experienced systemic hypotension following reduction of the hernia; mean arterial pressure decreased to 50 mmHg and the capnograph waveform disappeared. Abdominal insufflation was briefly discontinued, after which mean arterial pressure returned to 79 mmHg and normal capnograph waveform returned. Insufflation was returned to 5 mmHg and systemic blood pressure remained stable until the thoracoscopic pericardial cyst resection. The diaphragmatic defect was closed using 2-0 barbed absorbable suture (V-Loc 180; Medtronic) in a single-layer simple continuous pattern using laparoscopic needle drivers (Karl Storz Veterinary Endoscopy) (Figure 3 B).

A 5-mm subxiphoid port (Karl Storz Veterinary Endoscopy) was placed and the endoscope used to visualize placement of a 5-mm thoracoport (Medtronic) in the ventral right 6th intercostal space. A window in the caudal mediastinum was created with the UVSD, and a 10-mm thoracoport (Medtronic) was inserted in the ventral left 6th intercostal space. The ventral pericardium was retracted and incised using the UVSD until the cyst was

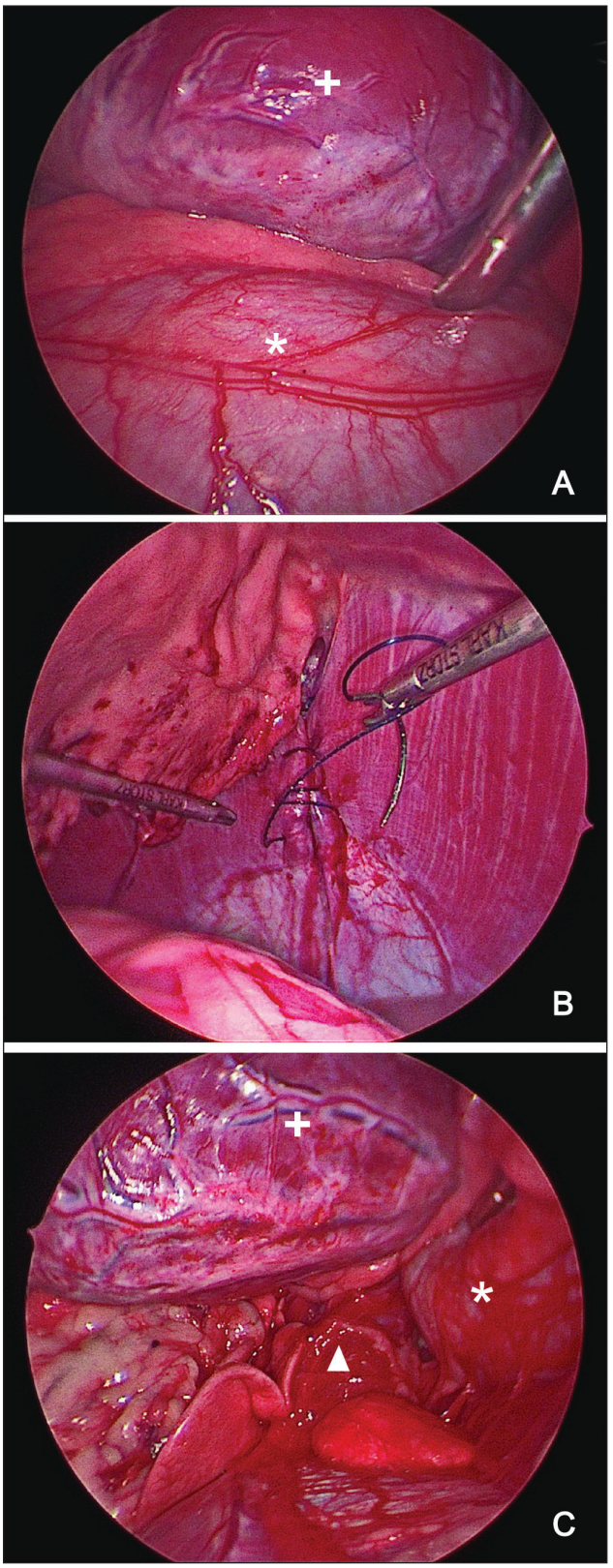

Figure 3. Intrapericardial cyst and PPDH repair in Case 2. A – Intrapericardial view *via* the diaphragmatic defect showing the epicardium (+) and ventral surface of the intrapericardial cyst (*) immediately caudal to the apex of the heart. B – Closure of the PPDH using a simple continuous pattern with barbed suture. C – View of caudal *vena cava* (Δ) and caudoventral surface of the heart (+) following resection of all but the dorsal wall of the intrapericardial cyst (*), retracted to the patient's left.

visualized between the heart and diaphragm; the ventral surface of the pericardium was resected to improve visualization. The outer wall of the cyst was incised with the UVSD, revealing numerous fibrous strands dividing pockets of omental fat and yellow-green translucent fluid. Due to the multiloculated nature of the cyst, it was removed in segments using laparoscopic grasping forceps and the UVSD. The caudal *vena cava* was visualized adjacent to the dorsal wall of the cyst; a small (~1 × 2 cm) portion of the dorsal cyst wall was left intact to avoid damage to the caudal *vena cava* (Figure 3 C). During manipulation of the cyst, the dog experienced repeated brief episodes of severe systemic hypotension that responded to repositioning the cyst to alleviate traction on the cyst or compression of the caudal *vena cava.* A CRI of norepinephrine (0.03 μg/kg per minute) was initiated in an attempt to combat the positional hypotension but was not observed to have an effect on blood pressure measurements. The cystic structure and pericardium were deposited in a specimen retrieval bag (ReliaCatch; Medtronic) and the right intercostal site was extended to a 3-cm mini-thoracotomy to facilitate retrieval of the bag and its contents. A 14-Fr 20 cm thoracic drain (MILA International, Florence, Kentucky, USA) was placed at the right 7th intercostal space and port sites were closed routinely.

The dog recovered uneventfully and received fentanyl (3 μg/kg per hour, IV), cisapride (0.8 mg/kg, IV, q8h) to reduce the risk of post-operative aspiration due to the dog's history of regurgitation, and ondansetron (0.5 mg/kg, IV, q6h) while in hospital. The thoracic drain was removed 1 d after surgery and the dog was discharged 2 d after surgery with a transdermal fentanyl patch (50 μg), carprofen (1.9 mg/kg, PO, q12h), trazodone (3.7 mg/kg, PO, q8h), and cisapride (2.1 mg/kg, PO, q12h). Histopathological evaluation of the resected intrapericardial cyst revealed marked fibrosis with chronic hemorrhage, supporting the diagnosis of intrapericardial cyst; culture of the cystic tissue was negative. A follow-up telephone call with the referring veterinarian 7 mo after surgery confirmed that the dog was doing well with no additional syncopal episodes reported.

Discussion

The feasibility of laparoscopic surgical correction of PPDH in 2 dogs with good clinical outcome is demonstrated in this report. One major challenge associated with laparoscopic repair of diaphragmatic hernias is the unavoidable insufflation of the pericardial cavity when the peritoneal cavity is insufflated. In dogs, intrapleural pressures of ≥ 3 mmHg have been demonstrated to significantly decrease cardiac output and systolic and diastolic pressure (9,10). In cases of PPDH, the pleuroperitoneal interface is intact; thus insufflation of the pleural space does not occur unless this barrier is breached during dissection. Although little is known on the effects of selective pericardial insufflation in dogs, similar effects on cardiovascular parameters as those seen with intrapleural insufflation may be expected (9,10). This is suspected to be the cause of the intraoperative hypotension observed in both dogs reported herein.

Recommended abdominal insufflation pressures in dogs undergoing routine laparoscopy range from 10 to 15 mmHg, with complications including acid-base disturbances, decreased venous return, and impaired diaphragmatic excursion with decreased pulmonary function observed at higher pressures (11–13). The authors subscribe to recommendations derived from human medicine to use the lowest insufflation pressure that allows for adequate visualization of the operative field in order to minimize negative effects of peritoneal insufflation (11,14). In Case 1, when significant hypotension developed following insufflation, the maximal pressure was decreased to 5 mmHg and then to 3 mmHg before ceasing insufflation and opening a cannula outflow valve to allow intraperitoneal (and consequently pericardial) pressure to decrease. This was effective in restoring systemic blood pressure to normal, after which peritoneal insufflation was restarted at a maximum setting of 3 mmHg. In Case 2, insufflation was reduced from 5 to 3 mmHg when systemic hypotension was observed. In both cases, blood pressure responded rapidly to decreasing abdominal insufflation pressure. Although working room for suturing was limited at the lower (3 mmHg) insufflation pressures, visualization of the hernia remained sufficient for continued repair of the diaphragmatic defect. Based on these cases, the authors recommend initiating abdominal insufflation at 3 to 5 mmHg when approaching PPDHs laparoscopically. Because neither case demonstrated significant hypotension until after herniated contents were reduced, dogs may tolerate higher initial insufflation pressures if the herniated viscera seal the defect and prevent insufflation of the pericardium.

Reducing abdominal insufflation pressures created a challenge in visualizing and closing the diaphragmatic defect, particularly in Case 1 when insufflation was temporarily discontinued. One method of circumventing the challenges associated with inadvertent insufflation of the pericardial cavity is the use of lift laparoscopy, with the additional benefits of avoiding negative consequences of CO_2 pneumoperitoneum (15–17). Although insufflation was discontinued due to hypotension in Case 1, repair of the diaphragmatic defect was continued by applying upward traction to the single-incision port to lift the ventral abdominal wall and improve working room despite a temporary lack of insufflation. Visualization was also facilitated by the rigid arc of the caudal rib cage, which provided persistent elevation of the cranioventral abdominal wall. Although limitations of lift laparoscopy include decreased intrabdominal volume compared to CO_2 pneumoperitoneum, risks associated with pericardial insufflation and the location of PPDHs may make lift laparoscopy particularly valuable for laparoscopic repair of PPDHs (15).

Another challenge encountered during both procedures was the impairment of instrument movement during repair of the ventral-most aspect of the hernia caused by contact between the caudoventral body wall and medial thighs of the dog and instrument handles. These physical constraints made it difficult to place sutures at the ventral aspect of the hernia as the surgeon's hands encountered the dogs' body wall and medial hind limb when positioning the instrument tips at the ventral diaphragm. This may be mitigated by placing the instruments through 2 lateralized ports rather than a central single-incision port to minimize contact of the instrument handles with the body wall. Use of articulating instruments may also improve

range of motion while minimizing hand excursion. Similarly, use of a suture-assist device may facilitate PPDH closure by minimizing hand movement. Suture assist devices have been reported to decrease suturing time compared to conventional intracorporeal suturing (18). In addition, the suture-assist device subjectively facilitated easier placement of suture through the edges of the hernia due to ease of placement of the needle perpendicular to the caudal surface of the diaphragm compared to the angle achieved with laparoscopic needle drivers. Further study is indicated to determine whether use of a suture assist device provides specific advantages in laparoscopic PPDH repair.

In humans, chronic diaphragmatic hernias may have extensive fibrosis between herniated viscera and adjacent pleura, increasing risk of injury to the herniated abdominal viscera and lungs, and potentially necessitating conversion from laparoscopy to laparotomy (19). Due to the congenital rather than traumatic origin of PPDHs in dogs, herniated viscera in canine PPDHs may be less likely to form substantial adhesions compared with other types of diaphragmatic hernias, making laparoscopic repair of PPDHs more feasible. In previous reports of dogs undergoing surgical correction of PPDH, 0 of 28 (0%), 2 of 8 (25%), and 14 of 91 (15%) of dogs were reported to have considerable adhesions (1–3). Although adhesions may pose a risk for conversion of laparoscopy to open herniorrhaphy, combining a thoracoscopic approach with laparoscopy may allow for visualization and dissection of intrapericardial adhesions, facilitating reduction of herniated organs without conversion. In Case 2, thoracoscopy was required to resect the intrapericardial cyst following herniorrhaphy. Although the cyst could be visualized from within the pericardium during the laparoscopic approach, the dorsal location of the cyst adjacent to the caudal *vena cava* prevented resection *via* a laparoscopic and intrapericardial approach. To the authors' knowledge, this case report represents the second report of successful thoracoscopic intrapericardial cyst resection (20). Due to the association of PPDHs and intrapericardial cysts in dogs, surgeons should evaluate for the presence of intrapericardial cysts when considering surgical correction of PPDHs (21).

Outcome of surgical *versus* conservative management of PPDH in dogs in 2 restrospective studies determined that long-term prognosis was similar regardless of treatment method (2,3). As such, a strong recommendation for surgical correction in the absence of organ compromise remains controversial. Because minimally invasive surgery in dogs has been associated with decreased post-operative pain and wound complications, the laparoscopic approach described here may provide a useful alternative to open herniorrhaphy to prevent strangulation of bowel and other clinical sequelae in dogs with PPDH (6). Careful monitoring of abdominal insufflation and cardiorespiratory parameters, particularly following reduction of herniated viscera, is warranted. CVJ

References

1. Banz AC, Gottfried SD. Peritoneopericardial diaphragmatic hernia: A retrospective study of 31 cats and eight dogs. J Am Anim Hosp Assoc 2010;46:398–404.
2. Burns CG, Bergh MS, Mcloughlin MA. Surgical and nonsurgical treatment of peritoneopericardial diaphragmatic hernia in dogs and cats: 58 cases (1999–2008). J Am Vet Med Assoc 2013;242:643–650.
3. Morgan KRS, Singh A, Giuffrida MA, Balsa IM, Hayes G. Outcome after surgical and conservative treatments of canine peritoneopericardial diaphragmatic hernia: A multi-institutional study of 128 dogs. Vet Surg 2020;49:138–145.
4. Evans SM, Biery DN. Congenital peritoneopericardial diaphragmatic hernia in the dog and cat: A literature review and 17 additional case histories. J Vet Radiol 1980;21:108–116.
5. McClaran JK. Diaphragmatic and peritoneopericardial diaphragmatic hernias. In: Monnet E, ed. Small Animal Soft Tissue Surgery. 1st ed. Ames, Iowa: Wiley-Blackwell, 2013:278–285.
6. Walsh PJ, Remedios AM, Ferguson JF, Walker DD, Cantwell S, Duke T. Thoracoscopic versus open partial pericardectomy in dogs: Comparison of postoperative pain and morbidity. Vet Surg 1999;28:472–479.
7. Culp WTN, Acvs D, Mayhew PD. The effect of laparoscopic versus open ovariectomy on postsurgical activity in small dogs. Vet Surg 2009;38:811–817.
8. Landreneau RJ, Hazelrigg SR, Mack MJ, *et al.* Postoperative pain-related morbidity: Video-assisted thoracic surgery versus thoracotomy. Ann Thorac Surg 1993;56:1285–1289.
9. Polis I, Gasthuys F, Gielen I, *et al.* The effects of intrathoracic pressure during continuous two-lung ventilation for thoracoscopy on the cardiorespiratory parameters in sevoflurane anaesthetized dogs. J Vet Med 2002;49:113–120.
10. Daly CM, Swalec-Tobias K, Tobias AH, Ehrhart N. Cardiopulmonary effects of intrathoracic insufflation in dogs. J Am Anim Hosp Assoc 2002;38:515–520.
11. Milovancev M, Townsend KL. Current concepts in minimally invasive surgery of the abdomen. Vet Clin Small Anim 2015;45:507–522.
12. Duke T, Steinacher SL, Remedios AM. Cardiopulmonary effects of using carbon dioxide for laparoscopic surgery in dogs. Vet Surg 1996;1:77–82.
13. Williams MD, Murr PC. Laparoscopic insufflation of the abdomen depresses cardiopulmonary function. Surg Endosc 1993;7:12–16.
14. Neudecker J, Sauerland S, Neugebauer E, *et al.* The European Association for Endoscopic Surgery clinical practice guideline on the pneumoperitoneum for laparoscopic surgery. Surg Endosc 2002;16:1121–1143.
15. Watkins C, Fransson BA, Ragle CA, Mattoon J, Gay JM. Comparison of thoracic and abdominal cavity volumes during abdominal CO_2 insufflation and abdominal wall lift. Vet Surg 2013;42:607–612.
16. Fransson BA, Ragle CA. Lift laparoscopy in dogs and cats: 12 cases (2008–2009). J Am Vet Med Assoc 2011;239:1574–1579.
17. Kennedy KC, Fransson BA, Gay JM, Roberts GD. Comparison of pneumoperitoneum volumes in lift laparoscopy with variable lift locations and tensile forces. Vet Surg 2015;44:83–90.
18. Pattaras JG, Smith GS, Landman J, Moore RG. Comparison and analysis of laparoscopic intracorporeal suturing devices: Preliminary results. J Endourol 2001;15:187–192.
19. Thoman D, Hui T, Phillips E. Laparoscopic diaphragmatic hernia repair. Surg Endosc 2002;16:1345–1349.
20. Chen C, Fransson BA, Nylund AM. Intrapericardial cystic hematoma in a dog treated by thoracoscopic subtotal pericardectomy. J Am Vet Med Assoc 2017;250:894–899.
21. Sisson D, Thomas WP, Reed J, Atkins CE, Gelberg HB. lntrapericardial cysts in the dog. J Vet Intern Med 1993;7:364–369.