Video-assisted thoracoscopic division of the ligamentum arteriosum in two dogs with persistent right aortic arch

Kevin Isakow, BVSc; David Fowler, DVM, MVSc, DACVS; Peter Walsh, DVM, MVSc

- Video-assisted division of the ligamentum arteriosum can be performed successfully in dogs with minimal postoperative complications and hospitalization time.
- Single-lung ventilation and thoracic insufflation are not mandatory and standard instrumentation may be used for most of the procedure.

An 18-week-old sexually intact female mixed-breed dog (dog 1) was referred to the Western College of Veterinary Medicine for surgical correction of a persistent right aortic arch. Physical examination revealed that the dog was thin and weighed 8 kg (17.6 lb). An inspissated nasal discharge that was consistent with a history of chronic regurgitation and nasal reflux was detected. Complete blood count, BUN concentration, and urine specific gravity were within reference ranges. An esophageal contrast study performed by the referring veterinarian revealed that the esophagus was dilated in the cranial mediastinum; the dilatation tapered abruptly at the heart base. Thoracic radiographs taken prior to surgery revealed no evidence of pneumonia.

Hydromorphone (0.2 mg/kg [0.09 mg/lb] of body weight, IM) and midazolam (0.2 mg/kg, IM) were used for sedation, and propofol (4 mg/kg [1.8 mg/lb], IV) was used for induction of anesthesia. Routine endotracheal intubation and anesthetic maintenance by administration of isoflurane (1.5%) and oxygen was performed. A pressure-cycled ventilator set at a peak inspiratory pressure of 15 cm of water to maintain end-tidal P_{CO_2} at 40 to 50 mm Hg was used when thoracotomy was performed. Cefazolin (22 mg/kg [10 mg/lb], IV) was given every 2 hours during surgery and every 8 hours for 24 hours.

The dog was placed in right lateral recumbency and draped to include the left thorax and cranial aspect of the flank. The scapula and adjacent intercostal spaces were identified. A 1-cm skin incision was made at the fifth intercostal space near the costochondral junction. The cutaneous trunci, latissimus dorsi, and intercostal muscles were subsequently incised, and a Rochester-Carmalt hemostatic forceps was used to enter the thoracic cavity. A 10-mm rigid cannula was placed through this opening, and a 0° thoracoscope was inserted through the cannula. Cannulas were not used at any other sites. Two similar incisions were made at the fourth and sixth intercostal spaces slightly more dorsal than the first incision. The left cranial lung lobe was retracted by use of closed right-angled forceps through the portal at the sixth intercostal space. Two additional portals were made at the fourth and sixth intercostal spaces, a few centimeters dorsal to the aforementioned incisions, to improve access to the esophagus at the heart base and facilitate continued retraction of the cranial lung lobe, respectively.

The dilated esophagus was viewed cranial to the heart base where it obstructed identification of the aorta's origin and appeared constricted at the level of the main pulmonary artery. The vagus and phrenic nerves were identified as they coursed over the heart base. The mediastinal pleura in the region of the esophageal constriction was grasped with right-angled forceps and incised with Metzenbaum scissors by use of the 2 most dorsal portals (**Fig 1**). Blunt and sharp dissection continued, alternating between the use of Metzenbaum scissors and right-angled forceps and taking care to avoid the vagus nerve. Identification of the ligamentum arteriosum between the pulmonary artery and right aortic arch was enhanced by passing a stomach tube to the level of constriction. The ligamentum arteriosum was undermined until right-angled forceps could easily pass beneath it (**Fig 2**). Care was exercised to prevent inadvertent perforation of the esophagus. Two stay sutures were placed around the ligamentum arteriosum and grasped with right-angled forceps to facilitate its elevation from the esophagus. Two vascu-

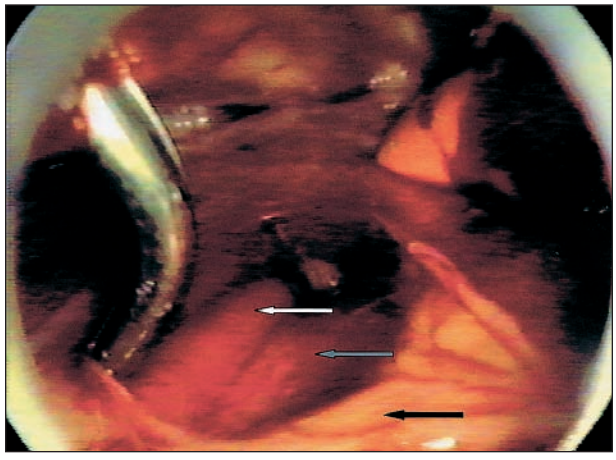

Figure 1—Thoracoscopic view of the cranial portion of the left hemithorax of a dog with persistent right aortic arch. A window created in the mediastinal pleura allowed viewing of the ligamentum arteriosum (white arrow), esophagus (gray arrow), and heart base (black arrow).

From the Department of Veterinary Anesthesiology, Radiology and Surgery, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, SN, Canada S7N 5B4. Dr. Walsh's present address is Veterinary Medical Teaching Hospital, School of Veterinary Medicine, University of California, Davis, CA 95616.

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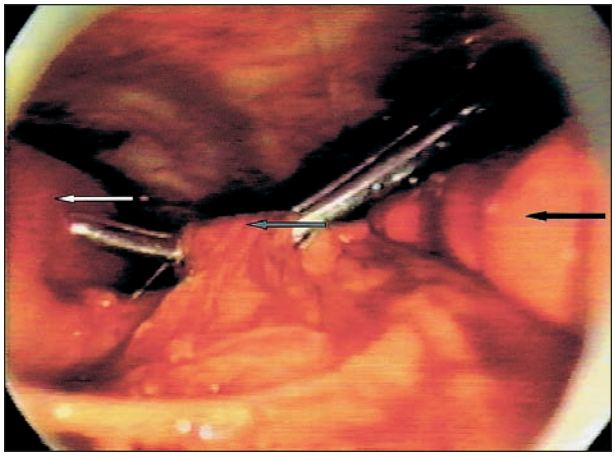

Figure 2—Thoracoscopic view of the cranial portion of the left hemithorax of a dog with persistent right aortic arch. The ligamentum arteriosum (gray arrow) is undermined with right-angled forceps. The dilated cranial portion of the esophagus (white arrow) and left cranial lung lobe (black arrow) are visible.

lar clips were applied to the ligamentum arteriosum, and Reynolds dissection scissors were used to divide it between the clips (**Fig 3**). Residual restrictive fibrous bands were broken down by use of blunt dissection, and the lung was repositioned. A gastroscope was advanced per os to view the esophagus and ensure that the constricted area was adequately dilated. A teat cannula, connected to an intravenous extension set and syringe, was inserted into the thorax through a stab incision at the eighth intercostal space. Incisions were closed with 3-0 polydioxanone suture in a cruciate pattern in the muscle and subcutaneous layers, and staples were used in the skin. Suction was applied to the preplaced teat cannula until negative pressure was achieved. The cannula was then removed. A percutaneous endoscopically placed gastrostomy tube was inserted.[1] Duration of surgery was 2 hours and 55 minutes. Three doses of oxymorphone (0.05 mg/kg [0.02 mg/lb], IM, q 4 h) were given after surgery. The dog was maintained on lactated Ringer's solution overnight.

One day after surgery, the dog cried briefly when lifted into or out of its cage but was otherwise bright, alert, and eager to eat. Lameness of the left forelimb was not detected, although lameness is commonly expected after open thoracotomy of the left fourth intercostal space. The dog was fed a gruel of commercial food[a] and water with the forelimbs elevated during ingestion of the meal. Only 1 episode of regurgitation was noticed during the first day after surgery.

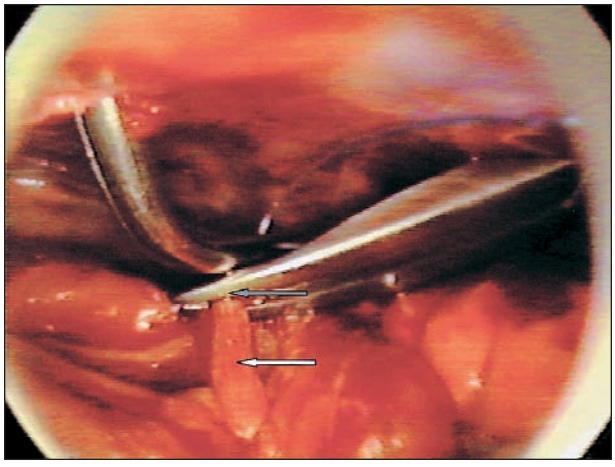

Figure 3—Thoracoscopic view of the cranial portion of the left hemithorax of a dog with persistent right aortic arch. A vascular clip (gray arrow) is applied to the ligamentum arteriosum (white arrow).

Fluoroscopy was performed 48 hours after surgery to evaluate esophageal motility. Esophageal dilatation persisted cranial to the divided vascular ring, but esophageal stricture was no longer evident, and motility of the distal portion of the esophagus was normal. The dog was discharged from the hospital with instructions to continue multiple small gruel feedings in an elevated position. The gastrostomy tube was not used and was removed 2 weeks after surgery.

By 4 months after surgery, the dog's body weight had doubled, and frequency of regurgitation had progressively decreased to once or twice a month. An esophageal contrast study performed at this time revealed persistence of esophageal dilation cranial to the site of original constriction. Fluoroscopy revealed good motility and peristalsis caudal to the stricture and decreased accumulation of ingesta cranial to the stricture, compared with results of the first study. Persistence of esophageal dilation did not detract from a favorable outcome, as is consistent with a previous report.[2]

A 12-week-old sexually intact female crossbred German Shepherd Dog (dog 2) had a history of intermittent regurgitation shortly after eating meals since weaning and was the runt of the litter. Results of an esophageal contrast study performed by the referring veterinarian were consistent with a vascular ring anomaly. On physical examination, the dog was thin, small for its age, and weighed 6.85 kg (15 lb). Results of CBC and serum biochemical analyses were within reference ranges. Thoracic radiographs revealed ventral deviation of the trachea and mild dilation and accumulation of fluid in the esophagus, cranial to the heart base. There was no evidence of respiratory tract disease or aspiration pneumonia.

The anesthetic protocol and surgical techniques used were the same as those used for dog 1, with the exception of portal location. On the basis of experience gained with dog 1, portal positions were modified for dog 2 (**Fig 4**). The thoracoscope was inserted through the fourth intercostal space at the costochondral junction, and additional portals were created dorsally at the third, fifth, and sixth intercostal spaces. A gastrostomy tube was not placed. Surgery time was 2 hours and 15 minutes.

The dog was given 1 dose of oxymorphone (0.1 mg/kg [0.045 mg/lb], IV) 4 hours after surgery. Thereafter, no additional analgesics were administered. The following day the dog appeared bright and alert, had no observable lameness in the left forelimb, and did not have signs of pain. An esophageal contrast study performed on the second day after surgery revealed that the esophagus was distended cranial to the heart, similar to findings in radiographs taken before surgery. There was gradual passage of contrast

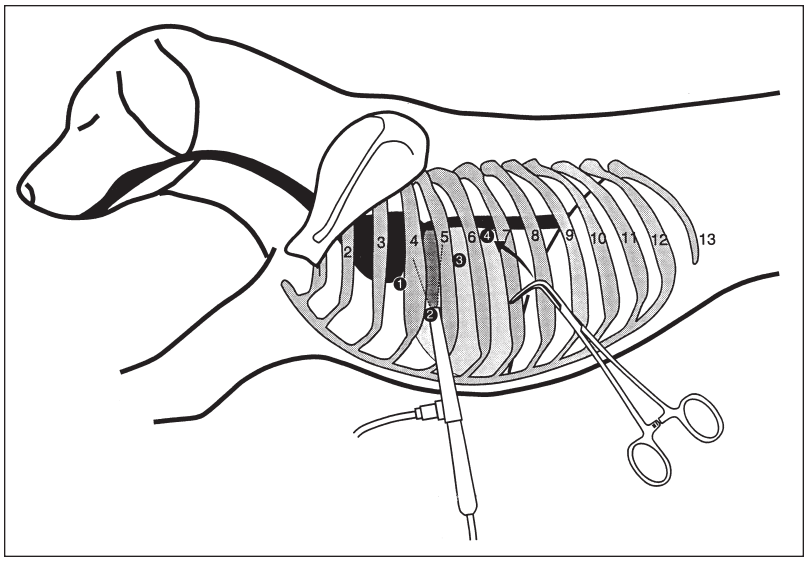

Figure 4—Diagrammatic illustration of video-assisted thoracoscopy in a dog, indicating recommended portal positions (encircled numerals). Portals at the third (No. 1) and fifth (No. 3) intercostal spaces are used for surgical manipulation. The thoracoscope is inserted through a cannula at the fourth intercostal space (No. 2), and right-angled forceps retract the left cranial lung lobe through a portal in the sixth intercostal space (No. 4).

material into the stomach with no notable retention caudal to the sacular dilatation. The dog was fed a gruel of commercial food[a] and water 4 times/d for the 3 days of hospitalization after surgery. Meals were fed with the dog's forelimbs elevated, and the dog was held in an upright position for 15 minutes after eating. No regurgitation was noticed for the duration of hospitalization after surgery. Six weeks later the owner was contacted by telephone for follow-up information. It was reported that the dog regurgitated approximately once per day, although the owners had reverted to feeding a semisolid diet.

Persistent right aortic arch is a congenital anomaly that results in entrapment of the esophagus between the base of the heart, aorta, and ligamentum arteriosum.[3] The goals of surgery are to transect the ligamentum arteriosum and ensure that bands of fibrous tissue do not restrict the esophagus.[3] The traditional surgical approach is via lateral thoracotomy through the left fourth intercostal space.[4] Video-assisted thoracic vascular ring division has been described in infants and children.[5] The technique is also described in a veterinary textbook,[6] but to the authors' knowledge, there are no case reports of thoracoscopic ligation and transection of the ligamentum arteriosum associated with persistent right aortic arch in dogs.

Insufflation is not routinely practiced when performing video-assisted thoracic surgery, because the thoracic wall does not collapse when pneumothorax is induced.[7] However, ventilation of a single lung with complete collapse of the ipsilateral lung has been considered mandatory for complete and safe viewing of the hemithorax and manipulation of instrumentation for most video-assisted thoracic procedures.[7] Ventilation of a single lung can be achieved by performing bronchial blockade, endobronchial intubation, or by use of double-lumen endotracheal tubes.[8] Technical expertise and the use of a fibre optic bronchoscope are necessary for successful single-lung intubation. In addition, tubes used for bronchial blockade may dislodge, and obstruction of the airways may result. Complete exploration of the hemithorax is not a requirement for this procedure, and a small surgical field of vision is necessary. In the procedures reported here, the left cranial lung lobe rarely interfered with viewing after it was reflected caudally, allowing complete exploration and identification of structures in the left hemithorax cranial to the heart base.

Although 7 types of vascular ring anomalies have been described,[9] type-1 anomalies (persistent right aortic arch with persistent left ligamentum arteriosum) account for approximately 95% of all vascular ring anomalies reported in dogs.[10] Therefore, contrast angiography and ultrasonography are often omitted, and the specific anomaly is confirmed at the time of surgery through a left lateral thoracotomy. Thoracoscopic viewing of the left hemithorax allows rapid confirmation of type-1 anomalies via identification of the dilated cranial portion of the esophagus, inability to view the aorta, and identification of a stricture of the esophagus at the level of the pulmonic trunk. After dividing the ligamentum arteriosum, an aberrant left subclavian artery may be identified slightly more cranially on the esophagus. An aberrant right subclavian artery, double aortic arch, or right ductus arteriosus may require a right-sided thoracotomy.[11] Thoracoscopy would decrease the complications associated with bilateral thoracotomies in such instances.

Intercostal nerve blocks, intrapleural or epidural instillation of local anesthetics, and use of injectable analgesics are commonly used in animals undergoing thoracic surgery because of the pain associated with thoracotomy. Postoperative pain and hospitalization are likely to be reduced by use of a video-assisted tech-

nique.[12,13] Minimal postoperative signs of pain were detected in the dogs reported here, which supports this hypothesis. Intercostal nerve blocks would also be beneficial in dogs undergoing thoracoscopic procedures because of the modest intercostal trauma created by cannula placement. Minimally invasive procedures are not without complication. The inadvertent penetration of lung or vascular structures may require conversion to an open procedure. Therefore, the patient should be prepared and draped accordingly, and instruments should be readily available.

Standard instrumentation was used for most of the procedures reported here. This avoids the necessity of maintaining an array of specialized laparoscopic instruments. However, the 2-dimensional television image and lack of depth and tactile perception may make surgery more difficult for the novice. The use of specially designed laparoscopic instruments should be encouraged, because they facilitate tissue manipulation and can be passed through cannulas with less subsequent trauma to the intercostal muscles, nerves, and vessels.

On the basis of our experience with the 2 dogs reported here, we recommend the use of 1 cranial and 2 caudal portals in addition to the thoracoscopic portal (Fig 4). The thoracoscope should be placed in the fourth intercostal space and the other portals in the third, fifth, and sixth intercostal spaces. The portal at the sixth intercostal space is used to retract the left cranial lung lobe with right-angled forceps while the remaining 2 portals (1 cranial and 1 caudal to the thoracoscope) are used for surgical manipulation. Visibility and manipulation are enhanced by use of the baseball-diamond triangulation concept to position instruments.[14] A mirror image results if instruments are pointed toward the thoracoscope. The difficulty in manipulation that this may cause is prevented by pointing the thoracoscope and instruments in the same general direction. Viewing of the ligamentum arteriosum can be obstructed by the right ventricular outflow tract when using the fifth intercostal portal, as was done in dog 1. A 30° telescope may be better suited for this procedure, because angled telescopes enable one to look over the top of tissues and keep the telescope out of the way of surgical instruments.

Although surgical time associated with the use of a video-assisted technique is likely to be longer than that of an open approach, we believe that the potential decrease in complications justifies its use. With the use of laparoscopic instruments and a 30° telescope, we are confident that surgical time can be reduced even further as experience with the technique increases.

[a]Prescription diet canine/feline a/d, Hill's Pet Products, Topeka, Kan.

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