Comparison of mesenteric lymphadenography performed via surgical and laparoscopic approaches in dogs

Brigitte A. Brisson, DMV, DVSc; David L. Holmberg, DVM, MVSc; M. House, DVM

Objective—To determine whether injection of a mesenteric lymph node with iodinated aqueous contrast medium results in radiographic delineation of the thoracic duct and its branches, ascertain the ideal interval between injection and radiographic imaging, and evaluate mesenteric lymphadenography performed via laparoscopic and surgical approaches in dogs.

Animals—10 adult dogs.

Procedure—In each dog, a right paracostal laparotomy or a right laparoscopic approach was performed to identify a mesenteric lymph node for injection of an iodinated aqueous contrast agent (0.22 mL/kg [81.4 mg of iodine/kg]). Lateral radiographic views were obtained at 60, 120, 180, 240, and 300 seconds after injection.

Results—A mesenteric lymph node was identified and injected with contrast medium in each dog. Via paracostal laparotomy, lymph node injection resulted in successful lymphangiographic evaluation in 4 of 5 dogs, whereas via the laparoscopic approach, lymph node injection resulted in successful lymphangiographic evaluation in 2 of 5 dogs. In successful radiographic evaluations, injected lymph nodes, mesenteric lymphatics, and the thoracic duct and its branches were delineated. Radiographs obtained at 60 and 120 seconds after injection of contrast medium provided the most detail.

Conclusions and Clinical Relevance—Injection of a mesenteric lymph node directly with contrast medium appears to be a feasible technique for delineation of the thoracic duct and its branches in dogs and might be useful in small animals in which mesenteric lymphatic catheterization can be difficult and lymphangiography is more likely to fail. Refinement of the laparoscopic technique may provide a minimally invasive approach to lymphadenography. (*Am J Vet Res* 2006;67:168–173)

Direct mesenteric lymphangiography has been recommended as the imaging technique of choice for use before and after thoracic duct occlusion performed to treat chylothorax in dogs and cats.[1-3] Before ligation, lymphangiography allows radiographic localization and characterization of thoracic duct lesions and simplifies ligation by outlining the anatomic features of the duct and its branches.[1,2] After ligation, lymphangiography allows radiographic confirmation that all branches of the thoracic duct have been successfully ligated.[1,2] Disadvantages of performing direct mesenteric lymphangiography as described by Kagan and Breznock[4] include that an invasive abdominal procedure, usually a paracostal laparotomy, must be performed to allow catheterization of a mesenteric lymph vessel[1]; the diagnostic procedure lengthens the anesthetic period associated with thoracic duct ligation by approximately 1 hour[5]; and mesenteric lymphatic catheterization can be difficult, especially in physically small dogs and in cats.[3] However, direct mesenteric lymphangiography is preferred over direct peripheral (pedal) lymphangiography[6-9] or inguinal lymphangiography[10] because of the difficulty associated with identification, catheterization, and injection of small peripheral vessels. With this in mind, the ideal technique for lymphangiography would be minimally invasive and easy to perform and the duration of anesthesia would be minimal.

The purposes of the study reported here were to determine whether injection of a mesenteric lymph node with iodinated aqueous contrast medium results in radiographic delineation of the thoracic duct and its branches, ascertain the ideal interval between injection and radiographic imaging, and evaluate mesenteric lymphadenography performed via laparoscopic and surgical approaches in dogs. Our hypothesis was that direct injection of iodinated aqueous contrast medium into a mesenteric lymph node would result in adequate delineation of the thoracic duct and offer a simple and rapid alternative to mesenteric lymphangiography. We also hypothesized that mesenteric lymph node injection could be performed by use of a laparoscopic technique, precluding the need for an invasive abdominal surgical procedure.

Materials and Methods

Ten adult mixed-breed dogs that were already anesthetized for a terminal undergraduate surgical teaching laboratory were used immediately prior to euthanasia to perform this study. The experimental protocol was approved by the Ontario Veterinary College Animal Care Committee, and dogs were cared for according to the Canadian Council for Animal Care and Use Guidelines. Each dog was premedicated with acepromazine maleate[a] (0.05 mg/kg, IM) and hydromorphone[b] (0.05 mg/kg, IM). Anesthesia was induced with ketamine[c] (5 mg/kg, IV) and diazepam[d] (0.25 mg/kg, IV) and maintained with halothane in oxygen. Hydromorphone[b] was administered as required (0.05 mg/kg, IV, q 3 to 4 h) for additional analgesia. An isotonic crystalloid solution[e] was administered IV throughout the procedure at a rate of 10 mL/kg/h, and boluses were administered as needed to correct for blood loss.

Received March 21, 2005.
Accepted May 13, 2005.
From the Department of Clinical Studies, Ontario Veterinary College, University of Guelph, Guelph, ON N1G 2W1, Canada (Brisson , Holmberg) Dr. House's present address is Long Island Veterinary Specialists, 163 South Service Rd, Plainview, NY 11803.
Supported by the Ontario Veterinary College Pet Trust.
Presented at the 13th Annual Scientific Meeting of the European College of Veterinary Surgeons, Prague, July 2004.
Address correspondence to Dr. Brisson.

Each dog underwent 2 surgical procedures (splenectomy and cystotomy) that did not involve the mesenteric lymphatic system or thoracic cavity as part of the teaching laboratory; the dogs had been anesthetized for a period of approximately 8 hours before the study of this report was performed. In the first phase of the study, 5 dogs underwent injection of a mesenteric lymph node with contrast medium via a surgical approach (designated the surgical group). After standard closure of the midline abdominal incision (performed for teaching purposes), each of these 5 dogs was placed in left lateral recumbency and the right abdominal wall was clipped and aseptically prepared for surgery. A right paracostal approach to the abdominal cavity was performed. The ileocecocolic junction was identified and exteriorized. The mesenteric lymph nodes were identified and stabilized between the surgeon's (BAB or DLH) fingers to allow direct injection of aqueous contrast medium[f] (0.22 mL/kg [81.4 mg of iodine/kg]) through a 22-gauge hypodermic needle (a rapid manual injection was performed while leakage around the needle puncture site was minimized). If leakage was detected visually, the needle was readjusted to attempt injection of a different portion of the lymph node; the injection was discontinued if leakage persisted. At 60, 120, 180, 240, and 300 seconds after the calculated volume of contrast medium was injected, lateral radiographic views were obtained by use of a portable radiographic unit. After the last radiograph was obtained, the dog was euthanatized via an overdose of pentobarbital[g] administered IV.

In the second phase of the study, 5 dogs underwent injection of a mesenteric lymph node with contrast medium via a laparoscopic approach (designated the laparoscopic group). After standard closure of the midline abdominal incision (performed for teaching purposes), dogs were placed in left lateral recumbency and the right abdominal wall was clipped and aseptically prepared for surgery. Briefly, CO_2 insufflation of the abdominal cavity was performed to a pressure of 8 to 10 mm Hg. A 5-mm telescope portal was first placed in the mid-dorsal portion of the abdominal cavity, and the abdominal cavity was explored by use of a 5-mm, 0° laparoscope. Two 5-mm instrument portals were placed in the ventral aspect of the abdominal cavity (at cranial and caudal locations), and Babcock forceps were used to manipulate the intestines to allow identification of the cecum and the cecocolic junction. Once the cecum was identified, it was manipulated to allow observation of the mesentery root and mesenteric lymph nodes. Once a suitable lymph node was identified, it was stabilized by grasping the most adjacent loop of intestine with Babcock forceps. A 22-gauge, 2.5-inch spinal needle[h] was inserted through the abdominal wall under laparoscopic guidance and directed toward the lymph node. The lymph node was punctured and the needle was advanced a few millimeters to achieve nodal injection. In instances where the needle was too short to reach the lymph node, the insufflation pressure was decreased to allow the abdominal wall to relax, thereby permitting contact between the needle and lymph node. After removing the needle stylet, aqueous contrast medium[f] (0.22 mL/kg [81.4 mg of iodine/kg]) was injected into the lymph node (a rapid manual injection was performed while leakage around the needle puncture site was minimized). If leakage was detected visually, the needle was readjusted to attempt injection of a different portion of the lymph node; the injection was discontinued if leakage persisted. At 60, 120, 180, 240, and 300 seconds after the calculated volume of contrast medium was injected, lateral radiographic views were obtained by use of a portable radiographic unit. After the last radiograph was obtained, the dog was euthanatized via an overdose of pentobarbital[g] administered IV.

Injection-to-radiographic exposure times were marked on each radiograph, and serial radiographs for each dog were grouped and bagged by 1 investigator (MH). Serial radiographs for each dog were evaluated independently by 2 investigators (BAB and DLH) after completion of the study; during radiographic evaluations, the evaluators were unaware of each dog's identification and treatment group. Radiographs were evaluated for the presence of contrast medium in mesenteric lymph nodes, mesenteric lymphatics, the cisterna chyli, and the thoracic duct; for evidence of branching of the thoracic duct; and for evidence of contrast

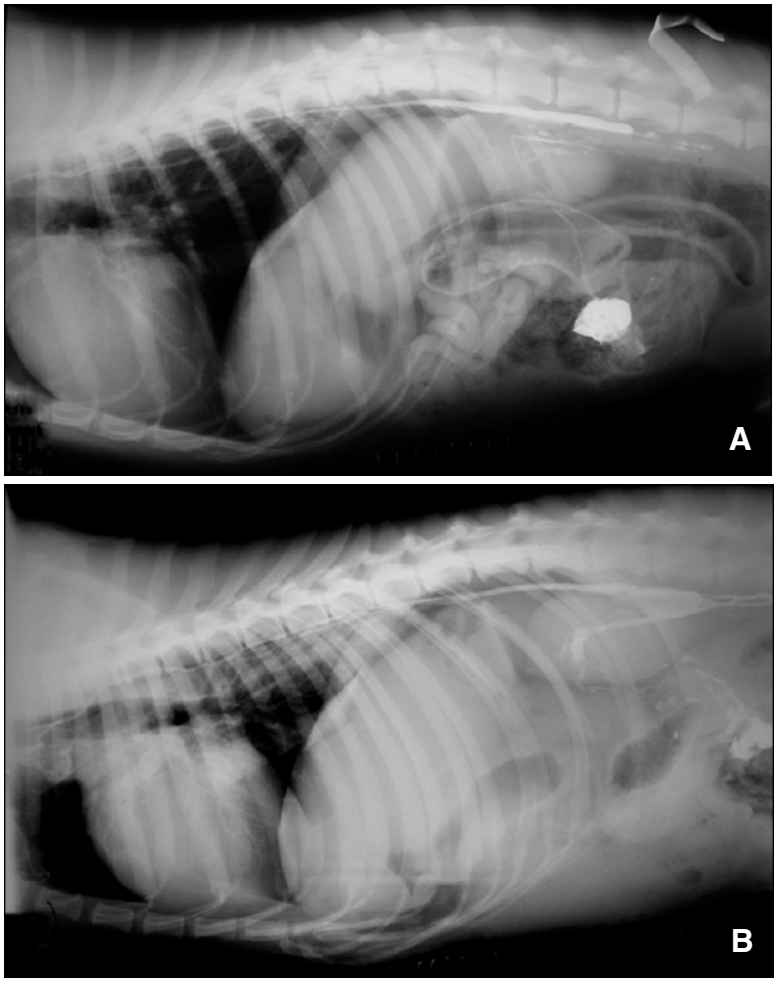

Figure 1—Right lateral radiographic views of the thorax and a portion of the abdomen of a dog, obtained 60 seconds (A) and 120 seconds (B) after direct injection of a mesenteric lymph node with iodinated aqueous contrast medium via a surgical approach. The injected lymph node, tortuous mesenteric lymphatic vessels, cisterna chyli, and thoracic duct and its branches are delineated by contrast medium. Note the convergence of branches at the level of the heart and the anastomoses cranial to the heart. In panel A, the radiopaque ribbon from a laparotomy sponge is visible in the top right corner of the radiograph.

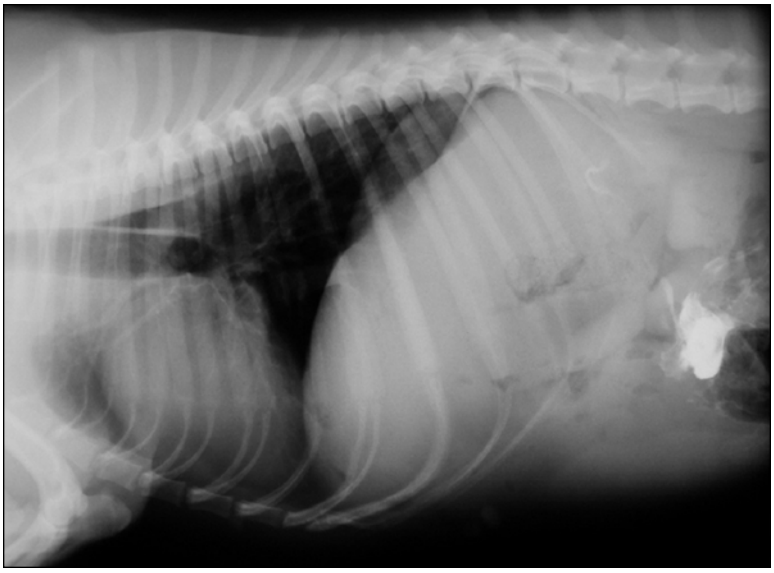

Figure 2—Right lateral radiographic view of the thorax and a portion of the abdomen of a dog, obtained 60 seconds after direct injection of a small mesenteric lymph node with iodinated aqueous contrast medium via a surgical approach. Notice that small, tortuous mesenteric lymphatics are delineated, but the thoracic duct is not visible. Contrast medium is concentrated within the lymph node and paranodal region.

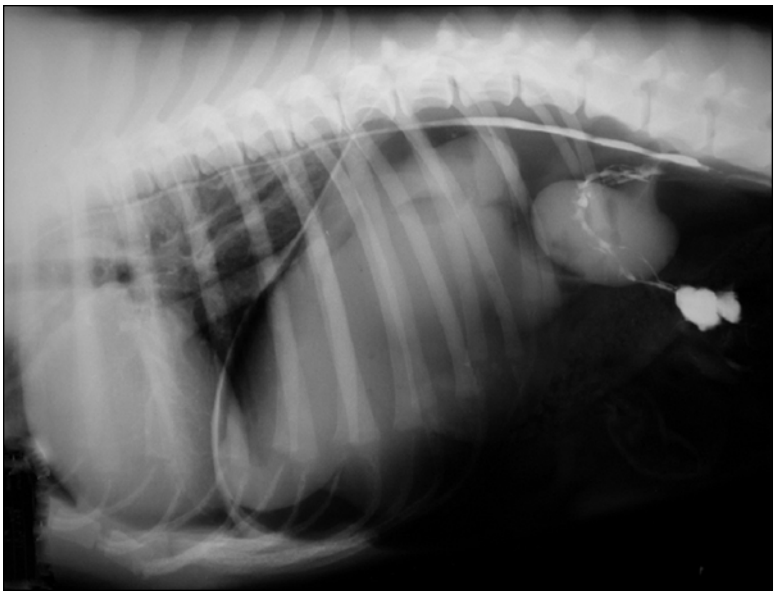

Figure 3—Right lateral radiographic view of the thorax and a portion of the abdomen of a dog, obtained 60 seconds after direct injection of a mesenteric lymph node with iodinated aqueous contrast medium via a laparoscopic approach. The injected lymph node, tortuous mesenteric lymphatic vessels, cisterna chyli, and thoracic duct and its branches are delineated. Notice the convergence and anastomoses of branches cranial to the heart.

medium flowing into the abdominal cavity. The most cranial flow of contrast medium in the lymphatic system and the time at which the radiographic evaluation was deemed most successful were also determined.

In 2 dogs in the laparoscopic group, the same lymph node into which the radiographic contrast medium was injected was later injected with 0.5 mg of methylene blue[i]/kg (1% solution; maximum dose of 10 mg of methylene blue). Following methylene blue injection and prior to euthanasia, thoracoscopic evaluation was performed in each dog via a single portal placed in the 10th intercostal space to visualize the thoracic duct.

Results

Mean weight of the dogs used in the laparoscopic group was 30.8 kg (weight range, 21 to 40 kg); mean weight of dogs in the surgical group was 25.5 kg (weight range, 13.3 to 30.5 kg). The dogs were purchased for the undergraduate surgical teaching laboratory, and this slight difference in group weights could not be controlled.

Mesenteric lymph node identification and injection were easily performed via a paracostal incision in all dogs. Duration of lymph node injection in the surgical group was 15 to 45 seconds. Lymphangiographic evaluations following paracostal laparotomy were successful in 4 of 5 dogs. Radiographically, the injected lymph node, tortuous mesenteric lymphatic vessels, cisterna chyli, and thoracic duct were delineated. All successful radiographic evaluations delineated the thoracic duct and its branches cranial to the diaphragm as well as anastomoses cranial to the heart (**Figure 1**). In 1 dog, the radiographic evaluation was not successful. That dog had small lymph nodes (approx 0.5 cm in diameter); as a result, there was substantial paranodal injection of contrast medium and poor flow of contrast in the lymphatic system. In this dog, radiographic evaluation revealed contrast medium concentrated in an area of the abdominal cavity (likely in a lymph node and the adjacent mesentery) as well as contrast medium spread throughout the abdominal cavity. Tortuous mesenteric lymphatics were evident radiographically, but the thoracic duct was not visible (**Figure 2**).

The ideal interval from injection to radiographic evaluation varied from dog to dog. Among the 4 successful injections in the surgical group, the most useful radiographic view was obtained at 60 seconds after contrast medium injection in 1 dog and at 120 seconds after contrast medium injection in 2 dogs; the radiographic views obtained at 120 and 180 seconds after contrast medium injection were equally useful in 1 dog. Most evaluations performed at 240 seconds after contrast medium injection provided less detail and did not delineate thoracic duct branches clearly. Evaluations performed at 300 seconds rarely revealed the presence of contrast medium cranial to the diaphragm. Overall, it appeared that radiography performed between 60 and 120 seconds after injection of contrast medium would provide most detail of the thoracic duct and its branches.

Laparoscopic identification of mesenteric lymph nodes was more tedious than surgical identification

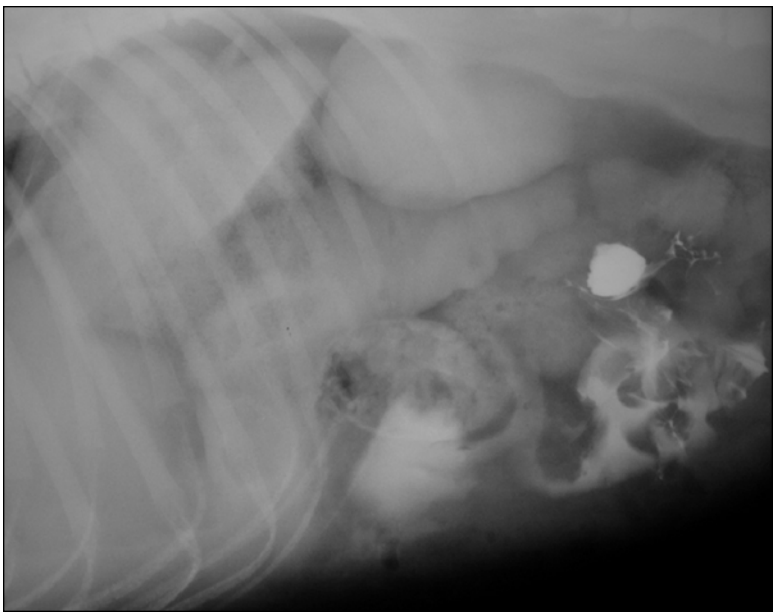

Figure 4—Right lateral radiograph of the caudal portion of the thorax and cranial portion of the abdomen obtained 60 seconds after direct injection of a mesenteric lymph node with iodinated aqueous contrast medium via a laparoscopic approach. The injected lymph node is visible, but contrast medium has spread throughout the abdominal cavity (celiogram); there is no delineation of mesenteric vessels or the thoracic duct.

but did not prolong the overall duration of the procedure. In the first 2 dogs in the laparoscopic group, the jejunum was grasped and traced by use of Babcock forceps until the ileocecocolic junction was identified. This technique lengthened the procedure by approximately 10 minutes. In the third, fourth, and fifth dogs in this group, the cecum was identified directly or the colon was grasped and manipulated in a retrograde fashion until the ileocecocolic junction was encountered; this resulted in more efficient identification of the mesenteric lymph nodes. The duration of lymph node injection in the laparoscopic group was 30 to 60 seconds. Injection of mesenteric lymph nodes resulted in excellent delineation of mesenteric lymphatics, the cisterna chyli, and the thoracic duct and its branches in 2 dogs (**Figure 3**). The ideal time for radiographic evaluation was at 60 seconds after contrast medium injection in both of those dogs. At 120 and 180 seconds after contrast medium injection, details of the thoracic duct were less clear but still detectable along the entire length of the duct. Contrast medium could be detected only to the level of the diaphragm at 240 and 300 seconds. In 3 dogs, mesenteric lymph nodes were identified and injected, but this did not result in flow of contrast medium in the thoracic duct. In 2 of 3 unsuccessful evaluations, contrast medium leaked in the abdominal cavity, resulting in a celiogram (**Figure 4**).

Overall, 6 evaluations in 10 dogs were deemed successful. All 6 dogs with successful evaluations had some degree of branching of their lymphatic system cranial to the diaphragm. Branching occurred at a level between T13 and L1 and between T4 and T5. In these dogs, all thoracic duct branches identified converged back together to form a single duct in a cranial location (Figures 1 and 3).

In 2 dogs that underwent injection of the same lymph node with methylene blue following the injection of radiographic contrast medium, the thoracic duct was easily identified thoracoscopically as a dark-blue vessel located along the dorsal aspect of the thoracic cavity.

Discussion

Results of the study reported here indicated that detailed delineation of the thoracic duct and its branches and lymphaticovenous anastomoses was possible via injection of iodinated aqueous contrast medium directly into a mesenteric lymph node. By use of a surgical approach, this procedure resulted in radiographic views with excellent detail of the features of interest at 60 to 120 seconds after injection in 4 of 5 dogs. In 1 dog, only a small lymph node was identified and injected; contrast agent did not flow beyond the mesenteric lymphatic vessels, and considerable leakage of contrast medium within the abdominal cavity suggested perinodal injection.

Efficient identification of mesenteric lymph nodes was possible in all dogs in the laparoscopic group. However, lymphadenography was considered successful in only 2 of 5 dogs in that group. A reason for poor flow of contrast medium in dogs of the laparoscopic group might be that the contrast medium could not be injected with as much pressure and as rapidly in these dogs, as it was in dogs of the surgical group, because of the lack of manual stabilization of the injected lymph node. In fact, the lymph node generally moved away from the needle during rapid or high-pressure injection. Compared with the surgical group, it is possible that the lower pressure developed during lymph node injection and a slower rate of injection could have led to fewer successful radiographic evaluations in the laparoscopic group. In 2 dogs in the laparoscopic group, contrast agent was spread throughout the abdominal cavity, which suggests that the lymph node may have retracted enough during injection to allow contrast to leak around the injection site or that the spinal needle used to inject the contrast medium inadvertently perforated through the far side of the lymph node capsule, resulting in mesenteric or peritoneal injection.

Other reasons for poor lymphatic flow might include individual dog variation and lengthy periods of anesthesia, blood pressure changes, and abdominal organ manipulation during the teaching laboratory (in which the dogs were involved prior to inclusion in the present study). Supporting these suggestions are the facts that the rate of lymphatic flow has been shown to be variable among dogs and significantly slower in anesthetized dogs, compared with the rate of lymphatic flow in conscious dogs.[11] Although factors such as the duration of anesthesia and organ manipulation could not be controlled in our study because the dogs were anesthetized for a day-long teaching exercise, those factors should have been similar for all study

dogs. It is also possible that the establishment and subsequent release of pneumoperitoneum in the laparoscopic group might slow or restrict flow of contrast medium within the lymphatic system as a result of changes in abdominal pressure. Lymphatic flow during pneumoperitoneum has not been evaluated specifically, but increased abdominal pressure has been associated with increased lymphatic flow.[11] Performing radiographic evaluations earlier than 60 seconds after injection and later than 5 minutes after injection in the dogs in which contrast medium was confined to a specific area of the mid-abdomen (assumed to be a mesenteric lymph node) might have resulted in visualization of the thoracic duct; however, this was not performed in our study.

Although mesenteric lymphangiography via a laparoscopic approach was successful in only 2 of 5 dogs in the present study, important benefits could be associated with this technique in a clinical setting, including decreased signs of pain and faster recovery after surgery. In a study by Radlinsky et al,[5] thoracoscopic thoracic duct ligation was performed in healthy research dogs; in each dog, a laparotomy was performed prior to thoracoscopic duct ligation to obtain a lymphangiogram, which increased the mean duration of the thoracoscopic procedure by 57 minutes.[5] Performing a laparotomy would limit the benefits of early postoperative recovery and decreased postoperative pain afforded by the thoracoscopic procedure. Lymphangiography via a laparoscopic approach combined with thoracoscopic thoracic duct ligation is likely to improve postoperative recovery.

Overall, radiographic evaluations involving direct injection of aqueous contrast medium into a mesenteric node successfully delineated mesenteric lymphatics, the cisterna chyli, the thoracic duct and its branches as far cranial as the thoracic inlet, and lymphaticovenous anastomoses in dogs. The radiographic detail of these anatomic features obtained with this procedure was similar to that obtained with lymphangiography performed via direct mesenteric lymphatic catheterization.[1]

The dose of contrast agent used in our study was considerably lower than that recommended for performing lymphangiography via catheterization of a mesenteric vessel (1 mL of contrast medium/kg diluted in 0.5 mL/kg of saline [0.9% NaCl] solution).[3] The dose of contrast medium used in the present study was based on results of a pilot study performed by the authors that revealed substantial abdominal leakage when volumes of contrast > 5 to 7 mL were injected into a mesenteric lymph node. Because abdominal leakage was deemed unlikely to result in a successful lymphangiogram, once a leak was detected visually in the present study, the needle was readjusted to attempt injection of a different portion of the lymph node; the injection was discontinued if leakage persisted. Although several lymphangiographic evaluations were successful in our study, it is possible that injection of larger volumes of contrast agent would have resulted in successful lymphangiograms in a larger number of dogs. Evaluation of the use of larger volumes of contrast medium and injection of multiple mesenteric lymph nodes (when possible) might improve results obtained by use of this study technique.

Limitations of the present study include the fact that the dogs involved had been anesthetized for > 8 hours and had undergone 2 abdominal surgical procedures immediately before commencement of our study. It is impossible to determine how these factors may have affected the flow of chyle and the contrast agent through the thoracic duct. In our study, we did not attempt to compare lymph node injection with a previously described mesenteric lymphatic catheterization technique.[1] Therefore, we could not determine whether all thoracic duct branches that would be delineated by use of lymphatic catheterization had been delineated by use of lymph node injection. However, the detailed radiographic views obtained in the present study (in which small branching was noted at the level of the thoracic inlet) suggest that all lymphatic branches were identified by use of the study technique. Although it is assumed that injection of a mesenteric lymph node with contrast medium would be faster than traditional mesenteric lymphatic catheterization (thereby shortening the required anesthetic period), this was not determined in our study.

In the present study, evaluations were made after 1 injection of a mesenteric lymph node with contrast medium; the study was not designed to determine whether a second injection in the same, or an adjacent, lymph node would also result in a successful lymphangiographic evaluation. Lymphangiography before and after thoracic duct ligation is typically recommended to determine the anatomic features of the thoracic duct prior to ligation and confirm that all branches have been ligated prior to cessation of anesthesia and recovery of the patient. Further studies to evaluate the feasibility and usefulness of performing multiple injections within 1 mesenteric lymph node or injections in multiple mesenteric lymph nodes would be of clinical interest. In the present study, a mesenteric lymph node in each of 2 dogs was injected with methylene blue after completion of the radiographic investigations. Thoracoscopic examination of the caudodorsal portion of the thoracic cavity in these 2 dogs revealed excellent demarcation of the thoracic duct and its branches by methylene blue, suggesting that the combination of agents could be used in clinical settings to determine the anatomic features of the thoracic duct and facilitate surgical identification of all its branches. In 1 study,[12] injection of popliteal and mesenteric lymph nodes with methylene blue revealed that duct coloration occurred within 10 minutes of direct node injection and persisted for 60 minutes.

On the basis of results of the present study, the authors propose that mesenteric lymph node injection via a surgical approach may be a viable alternative to lymphatic catheterization. Because lymphatic catheterization is usually performed distal to the lymph node, a surgeon would not be precluded from performing catheterization subsequent to mesenteric lymph node injection if that procedure failed to delineate the thoracic duct. However, it is possible that perinodal injection might make identification of a mesenteric lymphatic vessel more difficult in the area

of leaked contrast medium. Direct mesenteric nodal lymphangiography would be especially useful in physically small patients in which lymphatic catheterization is often difficult and lymphangiography is more likely to fail. Because of the timing of radiographic evaluation after lymph node injection and the fact that the contrast is injected directly in the lymph node, this technique is likely to be useful in practices where portable radiography or fluoroscopy is available in the surgery suite. In the present study, lateral radiographic views were obtained serially at 60-second intervals following injection of dogs that were in lateral recumbency. Although it is often impractical to obtain 2 radiographic views after lymph node injection via a surgical approach, lateral and ventrodorsal radiograph ic views provide superior detail regarding the exact location of the thoracic duct and its branches, compared with 1 radiographic view alone. On the basis of our experience, we believe that 2 radiographic views of the thorax could be performed between 60 and 180 seconds after lymph node injection in a clinical setting, especially if fluoroscopic equipment was available. With regard to the laparoscopic injection technique, further investigations are warranted to refine the procedure, determine the ideal dose of contrast agent that should be used, and determine whether lymph node injection can be successfully repeated (in the same or another node) via the laparoscopic approach after thoracic duct ligation in dogs.

a. Atravet, Ayerst Laboratories, Montreal, QC, Canada.
b. Numorphan, DuPont Pharma Inc, Mississauga, ON, Canada.
c. Vetalar, Vetrepharm Canada Inc, Belleville, ON, Canada.
d. Diazepam, SABEX Inc, Boucherville, QC, Canada.
e. Plasma-Lyte A, Baxter Corp, Toronto, ON, Canada.
f. Hypaque-M 76%, Nycomed Imaging AS, Picker International Canada Inc, Brampton, ON, Canada.
g. Euthansol, Schering-Plough Animal Health, Pointe-Claire, QC, Canada.
h. BD Spinal needle, BD Medical Systems, Franklin Lakes, NJ.
i. Methylene blue, SABEX Inc, Boucherville, QC, Canada.

References

1. Birchard SJ, Cantwell HD, Bright RM. Lymphangiography and ligation of the canine thoracic duct: a study in normal dogs and three dogs with chylothorax. *J Am Anim Hosp Assoc* 1982;18:769–777.
2. Birchard SJ, McLoughlin MA, Smeak DD. Chylothorax in the dog and cat: a review. *Lymphology* 1995;28:64–72.
3. Fossum TW. Chylothorax. Surgery of the lower respiratory system: pleural cavity and diaphragm. In: Fossum TW, ed. *Small animal surgery*. 2nd ed. St Louis: CV Mosby Co, 2002;805–812.
4. Kagan KG, Breznock EM. Variations in the canine thoracic duct system and the effects of surgical occlusion demonstrated by rapid aqueous lymphography, using an intestinal lymphatic trunk. *Am J Vet Res* 1979;40:948–958.
5. Radlinsky MG, Mason DE, Biller DS, et al. Thoracoscopic visualization and ligation of the thoracic duct in dogs. *Vet Surg* 2002;31:138–146.
6. Sheehan R, Hreshchyshyn M, Lin RK, et al. The use of lymphography as a diagnostic method. *Radiology* 1961;76:47–53.
7. Prier JE, Burton S, Skelley JF. Direct lymphangiography in the dog. *J Am Vet Med Assoc* 1962;140:943–947.
8. Skelley JF, Prier JE, Koehler R. Applications of direct lymphangiography in the dog. *Am J Vet Res* 1964;25:747–755.
9. Quick CB, Jander HP. Aqueous lymphangiography of the canine thoracic duct. *J Am Vet Radiol Soc* 1978;19:178–180.
10. Abernathy RE, Witte MH, Cole WR. Visualization of the thoracic duct by inguinal lymphangiography in the dog—a new technique. *Lab Anim Care* 1967;17:297–301.
11. Browse NL, Rutt DR, Sizeland D, et al. The velocity of lymph flow in the canine thoracic duct. *J Physiol* 1974; 237:401–413.
12. Enwiller TM, Radlinsky MG, Mason DE, et al. Popliteal and mesenteric lymph node injection with methylene blue for coloration of the thoracic duct in dogs. *Vet Surg* 2003;32:359–364.