Comparison of thoracic duct ligation plus subphrenic pericardiectomy with or without cisterna chyli ablation for treatment of idiopathic chylothorax in cats

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OBJECTIVE
To compare duration of surgery, recurrence rate, and survival time between cats with idiopathic chylothorax treated with thoracic duct ligation (TDL) plus subphrenic pericardiectomy (SPC) and those treated with TDL, SPC, and cisterna chyli ablation (CCA).

DESIGN
Retrospective case series with nested cohort study.

ANIMALS
22 client-owned cats surgically treated for idiopathic chylothorax from 2009 through 2014.

PROCEDURES
Patient and surgery data were collected from the medical records. Recurrence of chylothorax and survival time were assessed by medical record review and client interview. Comparisons were made between cats treated with TDL plus SPC (TDL-SPC group) and those treated with TDL, SPC, and CCA (TDL-SPC-CCA group).

RESULTS
15 cats were treated with TDL plus SPC, and 7 were treated with TDL, SPC, and CCA. Median duration of surgery was significantly briefer for the TDL-SPC group (80 minutes; range, 55 to 175 minutes) than for the TDL-SPC-CCA group (125 minutes; range, 105 to 205 minutes). Five cats (2 in the TDL-SPC group and 3 in the TDL-SPC-CCA group) had persistent pleural effusion 4 weeks after surgery. Chylothorax recurred in 2 cats (1/group). Median survival time in the TDL-SPC group was 774 days (range, 3 to 2,844 days) and in the TDL-SPC-CCA group was 380 days (range, 11 to 815 days); these values did not differ significantly.

CONCLUSIONS AND CLINICAL RELEVANCE
Addition of CCA to the surgical treatment approach for cats with idiopathic chylothorax was associated with a significantly longer duration of surgery with no better outcome than achieved with TDL plus SPC alone. (J Am Vet Med Assoc 2018;252:976–981)

In healthy cats and dogs, chyle drains from the intestinal lacteal vessels afferent to the mesenteric lymph nodes and efferent to the cisterna chyli, which lie retroperitoneally dorsal to the abdominal aorta. This milky fluid, composed of lymph and chylomicrons from triglycerides absorbed from the small intestines, then exits the cisterna chyli via the thoracic duct system retropleurally, emptying into the systemic venous system adjacent to the entry of the external and internal jugular veins into the cranial vena cava.1,2

Chylothorax, the accumulation of chyle within the pleural space, is rarely caused by trauma and is more often caused by impeded lymphatic drainage or in association with idiopathic lymphangiectasia. Traumatic causes of chylothorax typically involve damage to the thoracic duct, which are self-limiting and heal over several days.3 Impediments to drainage are typically from conditions that lead to an increase in systemic venous pressure (eg, right-sided heart failure, heartworm disease, pericardial effusion, or tricuspid dysplasia), although extramural compression from conditions such as neoplasia, thymoma, fungal granuloma, or lung lobe torsion has been reported.2,3-5 When the underlying cause of chylothorax can be identified, treatment should be directed toward that cause. When the cause cannot be identified, the chylothorax is considered idiopathic. Certain oriental cat breeds (ie, Siamese and Himalayan) are believed to be predisposed to idiopathic chylothorax.

Medical and surgical techniques have been described for the treatment of chylothorax in cats. Medical strategies include drainage of the pleural space in cats with respiratory compromise; reduction of the dietary amount of medium-chain fatty acids, which...
are sometimes absorbed directly into the portal blood stream; and administration of rutin, a bioflavonoid medication believed to stimulate proteolysis and chyle resorption by macrophages to reduce fluid accumulation and chronic fibrosis. In many cats with chylothorax, the condition is refractory to medical management and surgical intervention is required.

Surgical techniques described for cats with chylothorax include 1 or more of the following: caudal TDL, pericardial window procedure, SPC, pleuroperitoneal shunt placement, omentization of the pleural space, glue embolization of the thoracic duct, and CCA. Thoracic duct ligation has historically been used in most surgical treatments for affected cats. When TDL is successful, new lymphaticovenous communications form within the abdomen, allowing effective drainage of chyle before it enters the thoracic cavity. All branches of the thoracic duct must be attenuated for TDL to be effective. Strategies developed to visually examine the thoracic duct and confirm attenuation include fluoroscopic or CT lymphangiography. Intraoperative lymphangiography can be performed with methylene blue dye injected into a mesenteric or popliteal lymph node, allowing examination of the thoracic duct branches. Considerable variation exists among cats in the branching of the thoracic duct and between and among dogs and cats in the location of this vessel. The general surgical recommendation for dogs with chylothorax is a right-sided approach to thoracotomy and for cats is a left-sided approach. The recurrence rate for chylothorax in cats treated with TDL alone is reportedly as high as 60%. The goal of SPC is to decrease the pressure placed on the right side of the heart from chronic pericardial irritation and fibrosis. Removal of a portion of the pericardium allows improved lymphaticovenous drainage. A study showed that 80% of cats with idiopathic chylothorax treated with both TDL and SPC had resolution of chylous effusion within a median follow-up time of 20.6 months.

Cisterna chyli ablation has been proposed as an adjunct to TDL, with the aim of removing the reservoir of chyle supplying the thoracic duct, decreasing lymphatic duct hypertension during the healing process after TDL, preventing recanalization between the cisterna chyli and the thoracic duct, and promoting new lymphaticovenous anastomoses within the abdomen. In a study, involving healthy dogs, 3 dogs treated with TDL alone had diversion of lymphatic flow to the thoracic azygous vein and 5 of 6 dogs treated with both CCA and TDL had diversion of lymphatic flow within the abdominal cavity. Investigators in that study suggested that TDL alone would not be adequate to achieve diversion of lymphatic drainage from the pleural space. Findings of a case series involving 8 dogs with chylothorax suggested that outcome improved when CCA was combined with TDL, resulting in clinical resolution of chylothorax in 7 dogs. A randomized trial involving 23 dogs with idiopathic chylothorax revealed a higher resolution rate following TDL plus CCA (83%) than following TDL plus SPC (60%), although this difference in rates was not significant.

To the authors’ knowledge, no study has been performed to compare outcomes for cats with idiopathic chylothorax treated with TDL plus SPC with or without CCA. We hypothesized that performance of all 3 procedures to reduce restriction of the pericardium, attenuate the thoracic duct, and decrease lymphatic hypertension would be associated with a lower chylothorax recurrence rate than that achieved with just TDL plus SPC. In addition, we hypothesized that the addition of CCA to surgical treatment would increase the overall duration of surgery.

**Materials and Methods**

**Animals**

Medical records from Seattle Veterinary Specialists and the Michigan State University Veterinary Teaching Hospital were reviewed to identify cats that received a diagnosis of idiopathic chylothorax between January 1, 2009, and December 31, 2014. Cats with complete medical records and available follow-up information were included. Those with a diagnosed cause of chylothorax were excluded from the study.

**Data collection**

Data were collected from medical records regarding cat signalment; nature and severity of clinical signs at initial evaluation; findings of clinicopathologic testing, thoracic radiography, echocardiography, CT, cytologic examination of effusion samples, and histologic examination of tissue samples, if performed; pleural fluid triglycerides concentration; pleural fluid-to-serum triglycerides concentration ratio; surgical treatment performed; duration of surgery; nature of any postoperative complications; time to recurrence of pleural effusion; type of fluid associated with any recurrent pleural effusion, if available; and outcome. Pleural effusion was considered to have recurred when a cat initially had no pleural effusion for at least 28 days after surgery but then later developed pleural effusion. Pleural effusion noted within 28 days after surgery was considered to have been associated with the original chylothorax and was not considered recurrent but was considered persistent. Pleural effusion was considered persistent when thoracocentesis was required ≥29 days after initial surgery.

**Surgery**

Cats were grouped by the type of surgery performed. For cats treated with TDL and SPC (ie, the TDL-SPC group), the TDL had been performed via a left 9th or 10th intercostal approach or median sternotomy. On entry to the thoracic cavity, the mediastinum was dissected dorsal to the aorta. The tissue of all 3 procedures to reduce restriction of the pericardium, attenuate the thoracic duct, and decrease lymphatic hypertension would be associated with a lower chylothorax recurrence rate than that achieved with just TDL plus SPC. In addition, we hypothesized that the addition of CCA to surgical treatment would increase the overall duration of surgery.

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was used at the discretion of the surgeon. Ligation was performed with sutures, surgical clips, or both. Subphrenic pericardiectomy was performed through an additional fifth intercostal thoracotomy by means of sharp dissection, electrocautery, application of a vessel-scaling device, or a combination of these methods with the intention of removing as much pericardium as possible without damaging the phrenic nerves.

For cats treated with TDL, SPC, and CCA (ie, the TDL-SPC-CCA group), a similar fifth intercostal lateral thoracotomy approach had been used to complete the SPC. Pleural ports were placed at the surgeon’s discretion. The TDL and CCA were achieved through a single paracostal incision as described elsewhere that allowed simultaneous access to the caudal portion of the thorax and cranial portion of the abdomen. Intraoperative lymphangiography was performed by use of methylene blue dye injected into a right colic lymph node as described elsewhere. The cysterna chyli was identified and then ablated with Metzenbaum or tenotomy scissors.

Long-term outcome
Follow-up information was obtained from medical records and telephone conversations with owners. Follow-up time was defined as the time from surgery to the last known date of physical examination or owner contact. Survival time was defined as the time from surgery until last known follow-up or patient death. Cause of death was recorded as related to or unrelated to chylothorax. Chylothorax-related deaths were defined as death or euthanasia related to recurrence or persistence of pleural effusion.

Statistical analysis
Statistical analysis was performed by use of statistical software. Kaplan-Meier analysis was performed to determine the median time to recurrence of pleural effusion or death and median survival time for all cats and for cats in each surgical treatment group. Cats that were lost to follow-up or died of causes other than chylothorax were censored from analysis.

Survival times are reported as a median and mean owing to the wide data distribution.

Log-rank analysis was performed to determine whether survival times differed between treatment groups. The Wilcoxon rank sum test was performed to determine whether specific variables (duration of surgery; cat age and body weight; duration of clinical signs; pleural fluid-to-serum triglycerides concentration ratio; pleural effusion specific gravity, total protein concentration, and WBC count; number of previous thoracocentesis events prior to surgery; and total volume of pleural effusion collected prior to surgery) were significantly associated with survival time. Duration of surgery was reported as a mean value as well as median (range) because of a wide data distribution, and mean values were compared between treatment groups with the Student t test. Values of \( P < 0.05 \) were considered significant for all comparisons.

Results

Animals
Twenty-nine cats surgically treated for idiopathic chylothorax were identified in the original medical records search. Seven (24%) of these cats were excluded from the study because neoplasia had been diagnosed or the cats had not undergone the investigated procedures (TDL plus SPC or TDL, SPC, and CCA [3]). Types of neoplasia included lymphoma (2), pericardial angiomatous neoplasm (1), and pericardial sarcoma (1). The remaining 22 (76%) cats (14 castrated males and 8 spayed females) were included. Included cats were classified as domestic mixed breeds (n = 19 [86%]), Siamese (2 [9%]), and Ragdoll (1 [5%]). Clinical signs at initial evaluation included tachypnea (17 [77%]), dyspnea (17 [77%]), coughing (5 [23%]), lethargy (5 [23%]), hyporexia (2 [9%]), exercise intolerance (1 [5%]), and polydipsia (1 [5%]). Characteristics of cats, their disease, surgical treatment, and outcome were summarized (Table 1).

<table>
<thead>
<tr>
<th>Variable</th>
<th>TDL-SPC</th>
<th>TDL-SPC-CCA</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>6.7 (2.1–13.8)</td>
<td>7.1 (3.5–14.0)</td>
<td>0.86</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>6.0 (3.9–10.4)</td>
<td>5.1 (3.9–6.5)</td>
<td>0.14</td>
</tr>
<tr>
<td>Duration of clinical signs (d)</td>
<td>141 (1–1,825)</td>
<td>24 (1–105)</td>
<td>0.67</td>
</tr>
<tr>
<td>No. of previous thoracocentesis events</td>
<td>3.8 (1–32)</td>
<td>2.1 (1–4)</td>
<td>0.63</td>
</tr>
<tr>
<td>Effusion WBC count (cells/µL)</td>
<td>18,116 (297–114,070)</td>
<td>6,541 (2,510–10,790)</td>
<td>0.97</td>
</tr>
<tr>
<td>Effusion total protein (mg/dL)</td>
<td>5.3 (4.0–7.2)</td>
<td>5.0 (4.0–6.0)</td>
<td>0.80</td>
</tr>
<tr>
<td>Effusion specific gravity</td>
<td>1.032 (1.028–1.041)</td>
<td>1.032 (1.029–1.037)</td>
<td>0.88</td>
</tr>
<tr>
<td>Serum triglycerides (mg/dL)</td>
<td>113.5 (23–342)</td>
<td>77.2 (29–221)</td>
<td>—</td>
</tr>
<tr>
<td>Pleural fluid triglycerides (mg/dL)</td>
<td>1,617.2 (252–4,563)</td>
<td>1,966.7 (998–3,703)</td>
<td>0.12</td>
</tr>
<tr>
<td>Pleural fluid-to-serum triglycerides concentration ratio</td>
<td>18.6 (6.3–54.1)</td>
<td>42.3 (12.1–105.8)</td>
<td>0.03</td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>95 (80 [55–175])</td>
<td>136 (125 [105–205])</td>
<td>0.03</td>
</tr>
<tr>
<td>Survival time (d)</td>
<td>774 (3–2,844)</td>
<td>380 (11–815)</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Values for all variables are reported as median (range), except for duration of surgery, which is reported as mean (median [range]) owing to a wide data distribution.
— = Not calculated.
Preoperative hematologic abnormalities included lymphopenia (n = 6 [27%]), neutrophilia (2 [9%]), anemia (2 [9%]), hyperglobulinemia (2 [9%]), azotemia (2 [9%]), leukopenia (1 [5%]), and hypernatremia (1 [5%]). Bacterial culture of pleural fluid samples was performed for 5 cats, and results were negative in all instances.

Thoracic radiography was performed for all 22 cats, revealing pleural effusion in all cats. Additional radiographic findings included lung lobe atelectasis (n = 5 [23%]), multiple chronic healed and acute rib fractures (1 [5%]), suspected abdominal mass identified as gastric foreign material on CT scan (1 [5%]), and suspected cranial mediastinal mass that was not confirmed with subsequent CT scan (1 [5%]). Computed tomography was performed for 12 (55%) cats, revealing pleural effusion in all cats. Additional CT findings included pulmonary atelectasis (n = 7), sternal lymph node enlargement (5), pleural thickening (4), multiple chronic healed and acute rib fractures (1), and pneumothorax of suspected iatrogenic origin (1). Thoracic ultrasonography was performed for 6 (27%) cats, revealing pleural effusion in all cats and parietal pleural thickening in 1 cat. Echocardiography was performed for 21 (95%) cats, and the heart had an unremarkable appearance in 16 (76%) of these cats. In the remaining 5 (24%) cats, mild changes such as mild valvular insufficiency were appreciated but were deemed of insufficient severity to have caused the chylous effusion.

Four cats had lung lobectomies performed owing to suspicion of pulmonary fibrosis. Three of these cats had a lung biopsy specimen submitted for histologic evaluation, revealing pulmonary fibrosis in 2 cats and partial lung lobe torsion in the remaining cat. Histologic examination of pericardial tissue was performed for 18 (82%) cats, revealing pulmonary fibrosis in 2 cats and partial lung lobe torsion in the remaining cat. Histologic examination of pericardial tissue was performed for 18 (82%) cats, revealing mild to moderate lymphocytic or plasmacytic pericarditis with various amounts of fibrosis. No neoplastic lesions were identified.

Treatment

In 15 (68%) cats, TDL plus SPC had been performed; in the other 7 (32%) cats, TDL, SPC, and CCA had been performed. A left 9th or 10th intercostal approach had been used for 14 cats in the TDL-SPC group, and a median sternotomy approach had been used for the remaining cat. Pleural ports were placed in 4 cats in the TDL-SPC-CCA group. Six cats in the TDL-SPC group and 4 in the TDL-SPC-CCA group required provision of supplemental oxygen prior to definitive treatment. In 2 cats in the TDL-SPC group and 3 in the TDL-SPC-CCA group, the pleural effusion persisted for at least 28 days after surgery. One cat in each group had recurrence of chylothorax.

Both mean and median duration of surgery were significantly (P = 0.03) briefer in the TDL-SPC group than in the TDL-SPC-CCA group (Table 1). No significant difference between groups was identified in median values for cat age or body weight, duration of clinical signs; number of thoracocentesis events prior to surgery; effusion WBC count, total protein concentration, or specific gravity; and serum triglycerides concentration, pleural fluid triglycerides concentration, and ratio of pleural fluid to serum triglycerides concentrations.

Outcome

Four (18%) cats died within 4 weeks after surgery. One cat in the TDL-SPC group died suddenly of cardiac arrest 3 days after surgery. No necropsy was performed. One cat in the TDL-SPC-CCA group developed cardiac arrest 6 days after surgery because of tension pneumothorax, and the owner elected euthanasia after the cat was revived. An additional 2 cats in the TDL-SPC-CCA group were euthanized 9 days after surgery because of persistent chylous effusion. Only 1 of these 2 cats had a lung lobectomy performed concurrently with the other listed procedures. One cat in the TDL-SPC group was lost to follow-up 17 days after surgery but had been doing well until that time.

Long-term follow-up information was available for the remaining 17 (77%) cats (13 in the TDL-SPC group and 4 in the TDL-SPC-CCA group), for a median follow-up period of 403 days (range, 69 to 2,844 days) after surgery. Persistent chylous effusion was noted in 5 of 17 cats 28 days after surgery (2/13 in the TDL-SPC group and 3/4 in the TDL-SPC-CCA group). One cat in the TDL-SPC group had evidence of persistent effusion during the 28-day recheck period but was not clinically affected until 11 months after surgery, when CCA was performed and a pleural port was placed. This effusion did not resolve after CCA, but the cat was managed with the pleural port as needed. The other cat in the TDL-SPC group had evidence of serosanguinous effusion 2 weeks after surgery. A pleural port was placed 4 weeks after surgery because of the persistent effusion. At 6 weeks after the TDL-SPC procedure, the effusion continued to persist and was identified as chylous. Cisterna chyli ablation was performed 8 weeks after the initial surgery, and the cat died at home 2 days later. No necropsy was performed. Two cats with persistent effusion in the TDL-SPC-CCA group had resolution of the condition by 3 months after surgery, and the other died suddenly 3 months after surgery.

Recurrence of chylothorax was reported for 2 of 17 cats (1/13 in the TDL-SPC group and 1/4 in the TDL-SPC-CCA group) at 760 and 350 days after surgery, respectively. The cat in the TDL-SPC group had been noted to have some persistent effusion at the 2-week recheck examination but did not require intervention until 760 days after surgery. The effusion was deemed chylous, and the cat was euthanized 774 days after surgery because of suspected pulmonary fibrosis. A necropsy was not performed. The cat in the TDL-SPC-CCA group developed congestive heart failure and was euthanized.

The 13 cats in the TDL-SPC group had a median survival time of 774 days and mean survival time of 499 days (range, 3 to 2,844 days). Respective values...
for the 4 cats in the TDL-SPC-CCA group were 380 days and 234 days (range, 11 to 815 days). Median survival times did not differ significantly ($P = 0.47$) between these groups.

**Discussion**

Findings of the present study involving a limited cohort of cats with idiopathic chylothorax suggested that addition of CCA to the surgical treatment approach did not result in a significant improvement in survival time or recurrence rate. No significant differences were identified between cats treated with TDL plus SPC and those treated with TDL, SPC, and CCA in signalment, clinical signs, preoperative clinicopathologic values, or pleural effusion characteristics. Persistence of chyloous effusion at 28 days after surgery was observed in 5 of 17 cats with available follow-up data. This 28-day period was chosen because it was a common reexamination point and because this period has been used in other studies.\(^8,19-21\)

In healthy dogs treated with TDL, lymphaticovenous anastomosis (as determined via repeated lymphangiography) has been identified 31 to 37 days after surgery.\(^11\) Similar information has not been reported for cats. Of the 5 cats that had persistent pleural effusion in the present study, one had resolution of the effusion by 3 months after surgery and another died of an unknown cause within that same period. Persistence of effusion beyond 3 months was noted for 2 of the 17 cats with available follow-up information, and this failed to resolve even with additional surgical procedures. Both cats initially had only TDL and SPC performed but later were treated with CCA and had pleural ports placed. This prolonged persistence could have been attributable to ineffective initial treatment or disease progression. Two cats in the present study (1/group) had late recurrence of chylothorax; however, no necropsy was performed for either cat and, given the small numbers and study design, no inferences could be made regarding the effect of CCA on outcome.

Although the usefulness of CCA has been explored in dogs,\(^11,16,17\) to the authors’ knowledge it has not been explored in cats and therefore this additional procedure may not justify the corresponding prolongation of anesthesia and increase in morbidity associated with surgery in a second (abdominal) body cavity. Duration of surgery in the present study was significantly longer for cats treated with versus without CCA, which was intuitive given that this was an additional procedure. With a single paracostal approach to the thoracic and abdominal cavities (as was used in the present study) to perform TDL and CCA, duration of surgery can be reduced to a mean of 133 minutes, but with that same procedure plus SPC via separate lateral thoracotomy, the median duration is reported 179 minutes.\(^18\) The time required to complete the surgeries in the present study should be interpreted with caution because the surgeries for cats treated with CCA had been performed at an academic institution by a surgery resident under the supervision of a board-certified veterinary surgeon and, therefore, may have involved a teaching component, thereby adding to the time.

Limitations of the present study included its retrospective nature, which precluded standardization of methods and data reporting. The surgeries were performed at 2 institutions by multiple surgeons, and the degree of experience of the primary surgeon was not documented, nor could standard surgical technique be confirmed. Lymphangiography had not been performed for all cats, so the degree of lymphatic attenuation achieved was based on surgeon perception at the time of surgery. Ideally, lymphangiography would have been performed for all patients at the time of surgery to ensure appropriate identification of lymphatic ducts. Postoperative procedural lymphangiography would also have been beneficial to ensure that adequate attenuation was achieved during surgery. Right-sided venous blood pressures were also not reported, so the benefit of pericardiectomy could not be evaluated. In addition, the number of included cats was small, limiting the statistical analyses that could be meaningfully performed and the generalizability of the findings. The small number of cats that underwent CCA could have been attributable to the lack of clinical evidence to support this procedure, the prolonged anesthesia, and other factors.

In the study reported here, no significant difference in outcomes was identified between cats with idiopathic chylothorax treated with TDL plus SPC with or without CCA. This finding, the shorter (albeit nonsignificantly) median survival time for cats treated with versus without CCA, and the longer duration of surgery involving CCA suggested no benefit to CCA for this group of patients. A prospective study would be necessary to further explore whether addition of CCA to TDL plus SPC treatment of cats with idiopathic chylothorax has some benefit. Ideally, in such a study, cats would be randomly assigned to treatment groups, lymphangiography would be performed to ensure all visible lymphatic tracts have been attenuated at the time of surgery, and a single surgeon and standardized protocol would be used to avoid some of the limitations noted here.

**Acknowledgments**

No external funding was provided for this study. The authors declare that there were no conflicts of interest.

**Footnotes**

a. Ligasure Atlas, Covidien Inc, Minneapolis, Minn.
b. Pleural access port, Norfolk Vet Products, Skokie, Ill.
c. SAS, version 9.3, SAS Institute, Cary, NC.

**References**


