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Thoracoscopic Pericardectomy Performed Without Pulmonary Exclusion in 9 Dogs

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Objective—To show the feasibility of thoracoscopic pericardectomy without pulmonary exclusion in dogs.

Study design—Prospective clinical study.

Sample population—Nine client-owned dogs.

Methods—Dogs referred for the treatment of pericardial effusion by thoracoscopic pericardectomy were intubated with a standard endotracheal tube, mechanically ventilated, and placed in dorsal recumbency. The thoracoscope was introduced into the thorax lateral to the xyphoid process. The operating instruments were inserted at the level of the ventral third of each sixth intercostal space. The pericardium was cut and retrieved through 1 instrument portal.

Results—Lung inflation did not interfere with the surgical dissection. A subphrenic pericardectomy was performed in all dogs without iatrogenic trauma. Operative time, from portal placement to skin closure, ranged from 60 to 100 minutes for the first 2 dogs and decreased to 30 to 45 minutes for the latter 7 dogs.

Conclusions—The reported technique avoids the need for selected intubation which requires special tubes, can be technically difficult to perform, and is not recommended in compromised animals in which bilateral lung ventilation is necessary to ensure adequate tissue oxygenation.

Clinical Relevance—Thoracoscopic pericardectomy offers several advantages over open techniques, including less postoperative pain and morbidity, shorter hospital stay, and improved cosmetic appearance. It can be performed without pulmonary exclusion.

PERICARDECTOMY IS considered a definitive treatment for benign or idiopathic pericardial effusion and a palliative treatment for malignant pericardial effusion.1,2 Open surgical resection via a lateral thoracotomy or a median sternotomy is the conventional method of performing this procedure.3 Recently, less invasive procedures have been developed in humans and in dogs, including percutaneous balloon pericardiostomy4,5, subxyphoidian pericardial window,6 and thoracoscopic pericardectomy.7,8 The advantages of minimally invasive endoscopic procedures have been established in humans and include less morbidity and shorter hospital stay.9,10 In dogs, thoracoscopy has been performed for several years,11-13 and recently thoracoscopic pericardectomy has been described.8,14,15

The previously reported technique involved pulmonary exclusion which can be detrimental in compromised animals and technically difficult to perform.15 In humans, with the help of a mediastinoscope, a transdiaphragmatic approach to the pericardium has been described without pulmonary exclusion.16 A technique for thoracoscopic pericardectomy in the dog that would incorporate the advantages of minimally invasive surgery without the disadvantages of pulmonary exclusion would be clinically useful. The objec-
tive of this study was to document the feasibility and results of thoracoscopic pericardectomy without pulmonary exclusion in dogs.

**MATERIALS AND METHODS**

Between January 1997 and July 1998, 9 dogs with clinical signs of cardiac tamponade were referred to the surgical department of Clinique Frégis for pericardectomy. All the dogs had undergone at least 2 successive ultrasound-guided pericardial drainage procedures a few weeks apart with cytologic evaluation of the fluid. Before surgery, the dogs were stabilized, and the pericardial fluid drained as needed. Preoperative data recorded included signalment, duration of effusion before surgery, and clinical signs. When the cytologic examination was highly suspicious for tumor cells, pericardectomy was considered palliative.

Operative complications, postoperative recovery, and the duration of postoperative drainage were recorded. The surgical time from portal placement to skin closure was noted. Follow-up information was obtained by telephone interview. Reevaluation, including ultrasonography, was performed at 3 and 6 months after surgery and then every 6 months.

**Surgical Technique**

A 10-mm zero-degree thoracoscope (Stryker endoscopy; 93290 Tremblay en France, France) was connected to a video camera (Stryker Endoscopy) and to a light source (Quantum 4000, Stryker Endoscopy). Images were viewed on a monitor and recorded. Operating instruments used included endoscopic scissors (Autosuture France, 78370 Plaisir, France) connected to an electrosurgical unit, endoscopic graspers (Autosuture France), and an irrigation-suction unit (Autosuture France).

After premedication with diazepam (0.2 mg/kg intravenously [IV]), anesthesia was induced with sodium thiopental (8 mg/kg IV). An endotracheal tube was placed, and anesthesia was maintained with isoflurane in oxygen at a 0.5% to 2.5% concentration. Ventilation was controlled with a volumetric ventilator (Seneca, Dräger, 78190 Montigny le Bretonneux, France) set at a tidal volume of 10 to 15 mL/kg and a frequency of 10 to 12 inspirations per minute. The dogs were monitored by means of an ECG, spirometer, pulse oxymeter, and capnograph.

The dogs were positioned in dorsal recumbency, and the chest was widely clipped and prepared for aseptic surgery. A 1-cm skin incision was made 1 cm lateral to the last sternebra at the junction between the costal arch and the xyphoid process on the left side. Through this incision a 1-cm trocar was introduced into the thoracic cavity at a point just cranial to the xyphoid attachment of the pars sternalis of the diaphragm. After moderate collapse of the lungs, the thoracoscope was inserted into the trocar and was directed cranially, lateral to the phrenopericardic ligament. Under thoracoscopic control, the operating instruments were introduced through 2 separate portals located ventrally at the sixth intercostal space on each side of the chest. An additional 5-mm skin incision was made at the ventral third of the left third or fourth intercostal space. Under thoracoscopic control, a curved hemostat bluntly penetrated the chest at this level and the irrigation-suction unit was then introduced.

To allow 360° visualization, the ventral mediastinum was dissected free from its sternal attachment (Fig 1). The pericardial sac was held with the endograsper (Fig 2) and opened with endoscissors (Fig 3). The sac contents were evacuated with the endoscopic suction unit (Fig 4). A partial pericardectomy leaving approximately 1 cm of pericardium ventral to the phrenic nerve was progressively performed using the endoscissors inserted through 1 side of the thorax with the endograspers providing traction from the other side (Fig 5). The pericardium was fragmented and retrieved from the thorax through 1 trocar hole. Samples of the pericardium were submitted for histologic examination. The thoracoscope was then used to examine the rest of the pericardial cavity to check for the presence of hemorrhage or tumors. The remaining pericardial sac and thoracic cavity were then lavaged. One thoracic drain was introduced and connected to a 3-way stopcock. Aspiration of the thoracic cavity was continued until negative pressure was obtained. Closure of the portal insertions sites was performed in a routine manner.

![Fig 1. Thoracoscopic view of the ventral mediastinum. The ventral mediastinum (small arrow) is cut with the 5-mm endoscissors attached to an electrocautery unit. The rib cage is seen in the background. The large arrow indicates the pericardium.](image-url)
Postoperative Treatment

A single dose of ketoprofen (2 mg/kg subcutaneously [SQ]) was administered after surgery.

Thoracic drainage was continued until fluid production was less than 1 mL per kg per day. The drain was then removed and the dog discharged from the hospital 24 hours later.

Results

The age of the dogs ranged from 3.5 to 10 years and the weight from 12 to 90 kg. Large breeds and male dogs (7/9) were overrepresented. Clinical findings included cardiac tamponade (8/9), ascites (5/9), pleural effusion (3/9), and cyanosis (1/9) (Table 1). A subphrenic thoracoscopic pericardectomy without pulmonary exclusion was successfully performed in all dogs. Total surgical time was 60 and 100 minutes in
the first 2 cases and subsequently decreased to between 30 and 45 minutes in the next 7. No iatrogenic trauma occurred in any dog.

Pulse oximetry and end-tidal CO₂ values (ETCO₂) remained within normal limits in all but 1 dog (no. 2). In this dog, the hemoglobin saturation fell to 70% and ETCO₂ reached 55 mm of Hg. These abnormalities were reversed by increasing the tidal volume and ventilation rate and by complete resolution of the pneumothorax at the end of surgery.

All dogs were able to lie down and did not show any obvious discomfort after surgery. Tachypnea was not observed. No immediate postoperative complications were encountered.

The duration of postoperative hospitalization ranged from 4 hours in case 1 to 5 days in cases 5, 6, and 8. Case 1 was an aggressive Saint Bernard that could not be managed by anyone but his owner. He had to be sent home with his thoracic drain in place.

Postoperative drainage was continued for a few hours to a few days (Table 1) except for 2 dogs that developed continued thoracic effusion and were euthanatized because of disseminated mesothelioma 45 days (case 7) and 60 days (case 2) after surgery.

Case 8 died at home 7 days after surgery. The drain was removed on the fifth postoperative day, and a protective thoracic bandage was applied. The owner, a physician, took his dog home against our recommendations. Twenty-four hours later, the dog developed tachypnea but was not brought back to the hospital despite our recommendations. The day after, the dog became cyanotic but was not readily returned to the hospital and died at home. A severe tension pneumothorax was suspected when the body was brought back to our emergency service.

Comparison of preoperative cytologic examination and postoperative histologic examination showed minor discrepancies (Table 2). In cases 1, 2, 3, 4, 5, 7, and 9, the cytologist’s primary diagnoses were consistent with the final histologic findings. In cases 6 and 8, some differences were observed. Nevertheless, in all cases except case 1, the cytologic examination could not completely exclude the possibility of tumor cells.

Six of the 9 dogs were alive at the time of reevaluation (6 to 18 months after the procedure) (Table 1). Ultrasound examination performed 3, 6 (6/9), and 12 (2/9) months after surgery did not show any recurrence of effusion or constrictive pericarditis.

**DISCUSSION**

Pericardectomy is considered to be the definitive treatment of recurrent benign pericardial effusion.³ It may also be a palliative treatment for malignant pericardial effusion.⁴ Heart base tumor was not diagnosed in any of the dogs in this study but in cases 2, 5, 7, 8, and 9, cytologic examination of the pericardial fluid revealed evidence of malignant cells. In all cases

<table>
<thead>
<tr>
<th>Case</th>
<th>Breed</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Weight (kgs)</th>
<th>Clinical Findings</th>
<th>Duration of Signs Before Surgery (d)</th>
<th>Drainage Duration (d)</th>
<th>Complications</th>
<th>Clinical Results and Duration of Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Saint Bernard</td>
<td>3.5</td>
<td>Male</td>
<td>90</td>
<td>Tamponade, Ascites</td>
<td>180</td>
<td>8</td>
<td>None</td>
<td>Excellent, 18 mo</td>
</tr>
<tr>
<td>2</td>
<td>Foxhound</td>
<td>8</td>
<td>Female, Neutered</td>
<td>12</td>
<td>Tamponade, Pleural effusion, Ascites</td>
<td>45</td>
<td>60</td>
<td>Persistent effusion</td>
<td>Euthanasia, 2 mo after surgery</td>
</tr>
<tr>
<td>3</td>
<td>Springer spaniel shepherd</td>
<td>10</td>
<td>Male</td>
<td>23</td>
<td>Tamponade, Ascites</td>
<td>30</td>
<td>1</td>
<td>None</td>
<td>Excellent, 9 mo</td>
</tr>
<tr>
<td>4</td>
<td>Beauce Shepherd</td>
<td>5</td>
<td>Male, Neutered</td>
<td>60</td>
<td>Tamponade, Pleural effusion, Ascites</td>
<td>80</td>
<td>2</td>
<td>None</td>
<td>Excellent, 12 mo</td>
</tr>
<tr>
<td>5</td>
<td>Boxer X</td>
<td>10</td>
<td>Male</td>
<td>40</td>
<td>Tamponade</td>
<td>30</td>
<td>3</td>
<td>None</td>
<td>Excellent, 8 mo</td>
</tr>
<tr>
<td>6</td>
<td>Pyrenean X</td>
<td>8</td>
<td>Male</td>
<td>26</td>
<td>Tamponade</td>
<td>150</td>
<td>5</td>
<td>None</td>
<td>Excellent, 9 mo</td>
</tr>
<tr>
<td>7</td>
<td>English shepherd</td>
<td>10</td>
<td>Male</td>
<td>43</td>
<td>Tamponade, Pleural effusion, Ascites</td>
<td>30</td>
<td>14</td>
<td>Persistent effusion</td>
<td>Euthanasia, 45 d after surgery</td>
</tr>
<tr>
<td>8</td>
<td>Boxer</td>
<td>9</td>
<td>Female</td>
<td>30</td>
<td>Cyanosis</td>
<td>4</td>
<td>5</td>
<td>Tension pneumothorax after drain removal</td>
<td>Died, 7 d after surgery</td>
</tr>
<tr>
<td>9</td>
<td>English shepherd</td>
<td>10</td>
<td>Male</td>
<td>40</td>
<td>Tamponade</td>
<td>120</td>
<td>8</td>
<td>No</td>
<td>Excellent, 6 mo</td>
</tr>
</tbody>
</table>
Table 2. Comparison of Results of Cytologic and Histologic Examinations

<table>
<thead>
<tr>
<th>Case</th>
<th>Cytologic Diagnosis</th>
<th>Histologic Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Benign cells</td>
<td>Idiopathic pericarditis</td>
</tr>
<tr>
<td>2</td>
<td>Mesothelioma</td>
<td>Subacute severe pericarditis</td>
</tr>
<tr>
<td></td>
<td>Chronic mesothelial hyperplasia</td>
<td>Mesothelioma (necropsy)</td>
</tr>
<tr>
<td>3</td>
<td>Chronic pericarditis</td>
<td>Chronic pericarditis</td>
</tr>
<tr>
<td>4</td>
<td>Idiopathic pericarditis</td>
<td>Idiopathic pericarditis</td>
</tr>
<tr>
<td>5</td>
<td>Mesothelioma</td>
<td>Sarcomatous mesothelioma</td>
</tr>
<tr>
<td>6</td>
<td>Chronic pericarditis</td>
<td>Mesothelioma</td>
</tr>
<tr>
<td>7</td>
<td>Mesothelioma</td>
<td>Mesothelioma</td>
</tr>
<tr>
<td>8</td>
<td>Histiocytoma</td>
<td>Pyogranulomatous pericarditis</td>
</tr>
<tr>
<td>9</td>
<td>Possible hemangiosarcoma</td>
<td>Possible hemangiosarcoma</td>
</tr>
</tbody>
</table>

For cases 2, 3, 5, 6, and 8, the cytologist gave several differential diagnoses. They are listed in order of highest probability (the most likely first). For cases 3 and 5, the histologist gave several differential diagnoses. They are listed in order of highest probability (the most likely first). In case 2 the initial diagnosis was subacute severe pericarditis. On necropsy it was found to be a mesothelioma.

but case 1, the cytologic examination could not completely exclude the possibility of tumor cells in the pericardial fluid (Table 2). Even with this possibility, the owners of these dogs were willing to pursue decompressive surgery. In 4 dogs (1, 3, 4, 8), the disease was benign. Two dogs had a malignant effusion—case 5 had a sarcomatous mesothelioma and case 9 a hemangiosarcoma. Both dogs were alive and clinically doing well at time of reevaluation. Based on the final histologic findings and clinical outcome, the initial cytologic diagnosis should not discourage owners from pursuing pericardectomy. Beside the use of cytologic examination of the fluid as a means of diagnosing the cause of pericardial effusion, other techniques, such as fluid pH determination, have been described but were not used in our cases.

Lateral thoracotomy or median sternotomy are the conventional surgical approaches for pericardectomy in dogs. Both cause postoperative pain because of muscle separation, pressure on intercostal nerves, and/or sternal splitting. These sources of pain are avoided with the thoracoscopic approach. In addition, thoracoscopic control of instrument placement and the absence of stability threads (devices designed to secure the trocar to the body wall) prevent additional trauma to the intercostal nerves. Although it is not objectively measured, the absence of postoperative pain was evidenced by the fact that the dogs were resting comfortably and had a normal respiratory rate upon recovery. More objective parameters have been used by others.

In previous reports, thoracoscopic pericardectomy in dogs has been described with the dog placed in lateral recumbency. In this position, proper visualization and dissection of the pericardium are possible only if the ipsilateral lung lobes are collapsed. This can be achieved by several means: by insufflating the chest unilaterally to create a unilateral tension pneumothorax or by selectively ventilating 1 lung. To create a unilateral tension pneumothorax, CO₂ is insufflated in 1 side of the chest. This significantly reduces gaseous exchange, increases shunting, and diminishes tidal volume. In addition, permeability or perforation of the mediastinum results in bilateral pneumothorax which leads to further respiratory compromise. Unilateral lung collapse can also be obtained by selective ventilation of the contralateral lung. This necessitates fibroscopic placement of specially designed endotracheal tubes to ventilate 1 mainstem bronchus. These tubes may be difficult to place accurately and are expensive. Furthermore, any technique of unilateral lung ventilation may be detrimental to proper tissue oxygenation and would be contraindicated in compromised animals. In the technique described here, as the dog is placed in dorsal recumbency the lungs fall dorsally by gravity, thereby allowing proper dissection and removal of the pericardium without compromising lung inflation. This is demonstrated by the fact that SpO₂ and ETCO₂ values remained within normal limits in all but 1 dog (case 2). In dog 2, the low SpO₂ and high ETCO₂ values could be explained by the dog’s underlying disease (concurrent pleural effusion and ascites) as well as by an incorrect ventilator setting. Moreover, SpO₂ and ETCO₂ values returned to normal after increasing the ventilation rate and the tidal volume.

Pericardectomy has been used in dogs weighing from 12 to 90 kg by using the same instruments. Use of a 10-mm rather than a 7-mm thoracoscope is necessary because a wide view of the thorax is needed throughout the procedure. For any thoracoscopic procedure, unipolar electrocautery is mandatory, and, if available, a bipolar electrocautery is recommended. In animals with chronic pericardial effusion, the pericardial sac is thickened and inflamed. Hemorrhage that occurs during the procedure needs to be carefully controlled by electrocoagulation. No iatrogenic surgi-
cal trauma occurred in any animal. This compares favorably with a previous report on thoracoscopic pericardectomy in which 2 phrenic nerve transections and 1 lung laceration occurred.12 There was no related morbidity or mortality specifically associated with the procedure in the 9 cases in this study. The lack of pulmonary exclusion did not increase the surgical risk.

In case 8, tension pneumothorax developed 2 days after the thoracic drain had been removed. At the time of drain removal, continued monitoring and hospitalization was recommended but was refused by the owner. A chest bandage was applied. We suspect that the bandage slipped caudally before the chest drain hole sealed. Twenty-four hours later, despite our strong recommendations, the owner refused to hospitalized the dog. The dog’s pneumothorax would have been cured by thoracocentesis. This complication was not related to surgical failure but to an irresponsible owner not willing to comply with basic medical recommendations.

Surgical time decreased significantly with experience. This is a characteristic of endoscopic procedures, since new surgical skills must be learned to operate efficiently. After the first 2 cases, which lasted up to 100 minutes, the average surgical time decreased to 45 minutes. This is much less than what is generally reported for open techniques2 and compares favorably with other thoracoscopic techniques performed under pulmonary exclusion.15 The lack of pulmonary exclusion did not lengthen the procedure.

The amount of pericardium to be removed is still debated. Whereas some investigators recommend a pericardial window,4-6 others advocate a subtotal pericardectomy.2,17 With the dog placed in dorsal recumbency, a 360° subphrenic pericardectomy, leaving approximately 1 cm of pericardium ventral to the phrenic nerves, can be achieved without interference from the lungs. Although it is not easily accomplished, the dorsal portion of the heart can be visualized by placing the thoracoscope between the remaining pericardium and the heart.

The length of hospital stay is mainly dependent on postoperative drainage and therefore on the nature of the underlying pericardial disease. However, other factors such as animal compliance and owner decisions may alter this. In cases 3, 4, and 5, the length of time of postoperative drainage was minimal (Table 1), and the dogs went home soon after drain removal. We believe that their hospital stay would have been longer with conventional pericardectomy. Dog 1 was sent home 4 hours after surgery with the thoracic drain in place because the dog was very aggressive and could not be handled by anyone but his owner. Although it is not current practice to send dogs home with a thoracic drain in place, this owner was medically educated and managed the thoracic drain until its removal 8 days after surgery.

Thoracoscopic pericardectomy offers several advantages over conventional open pericardectomy, including less postoperative pain and morbidity, shorter hospital stay, and improved cosmetic appearance. The paraxyphoid approach as used in our cases combines the advantages of thoracoscopic pericardectomy without the disadvantages of pulmonary exclusion.

ACKNOWLEDGMENT

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