Thoracoscopic pericardial window for management of pericardial effusion in 15 dogs

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OBJECTIVES: To report short-term complications and long-term outcomes of thoracoscopic pericardial window for management of pericardial effusion in dogs.

METHODS: Retrospective study of dogs in which thoracoscopic pericardial window was performed using a three-cannula technique. Surgery time, complications, postoperative management, area of resected pericardium, histopathology results and outcome were evaluated.

RESULTS: Diagnoses included dogs with idiopathic pericardial effusion (n=10), cardiac mass (n=4) and mesothelioma (n=1). One case required conversion to sternotomy. Median thoracoscopic surgery time was 52·5 (range, 45-80) minutes. Complications occurred in four (26%) cases. Median time to discharge was one (range, 1-6) day. Of dogs with idiopathic pericardial effusion, one is alive at 150 days, one was lost to follow-up at 180 days while eight were euthanased of which five were for unrelated reasons. All dogs with neoplastic causes died or were euthanased because of their illness. Median survival time for dogs with idiopathic pericardial effusion (635 days; range, 70-1165) was significantly longer than that for dogs with neoplasia (30 days; range, 1-107).

CLINICAL SIGNIFICANCE: Thoracoscopic pericardial window is of low morbidity with short surgery and hospitalisation times. It provides good long-term control of idiopathic pericardial effusion but short-term palliation of clinical signs in dogs with neoplastic disease.

INTRODUCTION

Pericardial effusion (PE) is the most common acquired pericardial disease in the dog and is usually either idiopathic or arises from a neoplastic process. In most affected cases, pericardiocentesis is initially indicated for rapid patient stabilisation. In recurrent PE of either idiopathic or neoplastic origin, pericardiectomy is indicated to facilitate drainage into the pleural cavity thereby reducing intrapericardial pressure and cardiac compression (Gibbs et al. 1982, Johnson et al. 2004, Humm et al. 2009). Prolonged survival is possible following pericardiectomy. In a previous study of dogs with PE without cardiac base masses detected by ultrasonography, the median survival time (MST) was 1218 days for those that underwent pericardiectomy compared to 532 days for those conservatively managed (Johnson et al. 2004). In another study of dogs with cardiac base masses there was a prolonged MST of 730 days post pericardiectomy compared to 42 days without pericardiectomy (Ehrhart et al. 2004). However, this prolonged survival is dependent on the type of neoplasia, as dogs with right atrial masses and suspected haemangiosarcoma do not have a significantly different survival time after pericardiectomy (Dunning et al. 1998).

Traditionally, pericardiectomy is performed by open thoracic surgery, either by median sternotomy or via an intercostal approach (Aronsohn & Carpenter 1999). Such procedures are usually confined to more specialised practices and may be refused by owners because of associated costs and perceived invasiveness. More recently less invasive techniques have been used, such as percutaneous balloon pericardiotomy (Cobb et al. 1996,
Bussadori et al. 1998, Sidley et al. 2002) or thoracoscopic pericardiectomy (Jackson et al. 1999, Dupré et al. 2001, Mayhew et al. 2009, Case et al. 2013). Thoracoscopic pericardiectomy has an additional benefit of offering better visualisation than traditional open thoracotomy by improving illumination and magnification to previously inaccessible areas (Walton 2001). It is also associated with less postoperative pain and lower morbidity (Walsh et al. 1999).

Two thoracoscopic pericardiectomy approaches have been described. The lateral approach was first described using one-lung ventilation (Jackson et al. 1999). For the alternative paraxiphoid approach, the animal is placed in dorsal recumbency and one-lung ventilation can be performed (Mayhew et al. 2009, Bauquier et al. 2010). However, one-lung ventilation is not necessarily required (Dupré et al. 2001). Using the paraxiphoid approach, two separate techniques have been described including a subphrenic pericardiectomy and a pericardial window. In the former technique, all the pericardium up to 1 cm ventral to the phrenic nerve is resected (Dupré et al. 2001, McCarthy 2005), while in the latter a smaller amount of pericardium is resected (McCarthy 2005). Subphrenic pericardiectomy is preferred in cases of constrictive pericarditis, infectious processes or neoplasia involving an extensive area of the pericardium, while the pericardial window can be used in other cases such as neoplastic effusions, haemorrhage from neoplastic masses, inflammatory disease and idiopathic effusions (McCarthy 2005). However, only a small number of cases undergoing thoracoscopic pericardial window have been reported, and there is a paucity of information regarding short-term complications and long-term outcomes.

The aim of this study was to describe the complications and outcome of a group of 15 dogs with PE managed by thoracoscopic pericardial window, without concurrent one-lung ventilation.

**MATERIALS AND METHODS**

**Case records**

Medical records for dogs that underwent thoracoscopic pericardial window technique at Davies Veterinary Specialists, UK, from January 2007 to August 2010 were retrospectively reviewed. Cases were included if they had a history of acute onset or recurrent episodes of PE secondary to neoplastic or idiopathic causes.

The age, sex, breed, history and clinical signs of the dogs were recorded. Data on procedures such as thoracic and abdominal radiographs, abdominal and thoracic ultrasonography, and pericardiocentesis (the number of pericardiocenteses performed before surgery) were collected. Surgery time, surgical complications, postoperative management and the outcome for each patient were also recorded. The area of resected pericardium and histopathology results were noted.

**Surgical technique**

Preadmission consisted of 0.3 mg/kg methadone (Physeptone Injection; Martindale Pharmaceuticals) intramuscularly (im) alone or in combination with 0.01 mg/kg acepromazine (ACP injection; Novartis Animal Health) im. Anaesthesia was induced with 1 to 4 mg/kg propofol (PropoFlo; Abbott Animal Health) intravenously (iv). A standard single-lumen endotracheal tube was placed and anaesthesia was maintained using isoflurane (IsoFlo; Abbott Animal Health) at concentrations between 1.5 and 2% in oxygen. Anaesthesia was maintained without one-lung ventilation in all dogs.

Each dog was positioned in dorsal recumbency and hair was clipped from the manubrium cranially to the umbilicus caudally and bilaterally to the mid-thoracic wall. The site was then prepared and draped for aseptic surgery. Thoracoscopic pericardial window was performed in all dogs using a three-cannula technique by a board-certified small animal surgeon with experience in thoracic surgery and minimally invasive surgical techniques.

The technique entailed initial placement of a 6 mm cannula (ref 62160, Karl Storz Veterinary Endoscopy) in a paraxiphoid position. A 5 mm 0° telescope (Karl Storz) was placed through this cannula to view the thoracic cavity. A pneumothorax was established and then a 6 mm cannula was placed under direct visualisation at the left sixth or seventh intercostal space at a position ventral to the costochondral junction. This cannula was established for instrument placement. A curved scissors (34310MW, Karl Storz) attached to monopolar electrocoagulation, was used to create a hole in the ventral mediastinum. This allowed visualisation of the right hemithorax and placement under direct visualisation of a similar 6 mm instrument cannula at the right sixth or seventh intercostal space, ventral to the costochondral junction. The remaining ventral mediastinum over the heart was then sectioned. Monopolar electrocoagulation was used exclusively for haemostasis of blood vessels within the mediastinum for the initial six dogs, but for later cases a bipolar laparoscopic electrocoagulation forceps (Advantage bipolar sealing instrument, Freelance Veterinary) was also utilised. Monopolar or bipolar electrocoagulation was not used for the pericardial incisions.

After visualisation of the cranioventral surface of the pericardium, it was grasped using a grasping forceps (33310ME, Karl Storz) and curved scissors were then used to create an initial hole on the pericardium. One arm of an EndoClinch™ forceps (EndoClinch™ 5 mm, Covidien) was then placed through the hole to allow a firm grasp of the pericardium to maintain its elevation. Subsequently, the initial grasping forceps was removed and curved scissors used to extend the incision from the initial hole. By rotating the EndoClinch, the pericardium was wrapped around the jaws of the instrument, thereby maintaining tension and accommodating extension of the incision until a portion of the pericardium was excised. The size of the defect in the pericardium (the pericardial window) was also evaluated thoracoscopically. Generally at least a 3 cm x 3 cm portion of pericardium was excised but the decision on the ultimate size of the window was based on subjective thoracoscopic evaluation and varied depending on the size of the dog. Additional strips of pericardium were excised to enlarge the window if the initial size was deemed insufficient. The excised pericardium was then extracted from the thoracic cavity, measured and submitted for histopathology. The authors did not have major difficulties extracting the excised pericardial segment from the thoracic cavity and specimen-retrieval bags were not utilised in any case. If possible the pericardial segment was extracted through the...
port, but more commonly this was extracted through the port incision site after removal of the port by careful manipulation of the grasping forceps and pericardial segment through the tissues of the chest wall. Major cannula-site enlargement was not necessary in any case. Care was needed when doing this to ensure that the pericardial segment was fully extracted but this was aided by thorascopic visualisation of the extraction procedure.

To evacuate the pneumothorax postoperatively, a thoracic drain (Portex Thoracic catheter, Smiths Medical) was placed under visualisation on either the left or right side. These were removed when pleural fluid evacuation decreased to <2 mL/kg/24 hours (Marques et al., 2009). Alternatively, following closure of the cannula sites, the air was evacuated by thoracocentesis, the exact procedure chosen being at the surgeon’s discretion. Following removal of the cannulas, the subcutaneous tissue and skin were routinely closed. Surgical time was measured from the first incision for initial cannula placement to final cannula-site closure.

Postoperative analgesia was provided following a general protocol of pain assessment. In all cases, 0-3 mg/kg methadone (Physeptone Injection; Martindale Pharmaceuticals) im every 4 to 6 hours, was administered initially. Once the animal’s level of comfort/pain was stable, a weaker opioid was employed [0-02 mg/kg buprenorphine (Vetergesic; Alstoe Animal Health) im every 6 hours. All cases were treated perioperatively with non-steroidal anti-inflammatory drugs [2 mg/kg carprofen (Rimadyl; Pfizer), orally every 24 hours] or 0-1 mg/kg meloxicam (Metacam; Boehringer-Ingelheim) orally every 24 hours and continued postoperatively the duration of which was at the discretion of the attending veterinarian based on assessment of pain and comfort.

Follow-up
Follow-up data were obtained by telephone communication with the referring veterinarians, and any additional veterinarians subsequently involved in the care of the patient. Outcome information was obtained by reviewing the medical records. If the dog had died, the date and presumed cause of death were recorded.

Statistics
Statistical analyses were performed using a computerized software package (Graphpad Prism, Version 6.0a, Graphpad Software). Descriptive statistics are presented as median (range). For the survival analysis, dogs were grouped into those with suspected neoplastic or idiopathic disease. Dogs still alive or lost to follow-up were censored. Kaplan–Meier survival curves were plotted and compared by the Mantel–Cox method (Fig 1). Statistical significance was defined as P<0.05. The hazard ratio was calculated using the log-rank method.

RESULTS

Clinical cases
The dogs ranged in age from 4 to 10 years with a median of 7 years. There were six females (five neutered) and nine males (four neutered). The breeds included four golden retrievers, and one each of Labrador retriever, Pyrenean mountain dog, Gordon setter, Saint Bernard, Airedale terrier, American bulldog, greyhound, crossbreed, Lakeland terrier, Staffordshire bull terrier and Border terrier. The median weight was 38 kg (range, 6-91).

The majority (n=11) of dogs were previously diagnosed with PE by the referring veterinarian while the remainder (n=4) were referred for investigation of exercise intolerance (n=3) and/or ascites (n=3). The median duration of clinical signs before thorascopy was 4 months with a range of 5 days to 7 months. Fourteen cases had previous pericardiocenteses [median, 2 (range, 2-3)].

Thoracic ultrasonography was used as the principal method for differentiating between idiopathic (n=10) and neoplasia-related (n=5) PE. No cardiac masses were detected in 11 cases, although mesothelioma was subsequently diagnosed in one of these dogs. Four cases had cardiac masses that were presumed to be neoplastic. These included one case each of a 3.5×2 cm diameter mass adjacent to the aortic arch and arising from the right auricle, a 2.5 cm diameter mass located on the right and dorsal aspect of the aorta and extending apically along the right ventricle and two cases each of 3.5 and 4.5 cm diameter masses extending between the aorta and pulmonary artery.

All four cases with cardiac masses were screened for possible metastases including thoracic radiography, thoracic and abdominal ultrasonography and in one case, thoracic and abdominal CT. Evidence of metastatic disease was only present in one case. In this case, there was a single multicavitated, 3 to 5 cm mass identified in the left side of the liver. The size and appearance of this lesion had been monitored for the preceding 7 months without any change. Two months before pericardiectomy, a second small hyperchoic mass was seen in the right side of the liver, adjacent to the gall bladder. One week before the pericardiectomy a third heterogeneous mass unrelated to the liver or spleen was detected within the mesentry. Previous thoracic radiographs had revealed a generalised interstitial pattern. The above findings were considered suggestive of metastatic disease.

Surgery and postoperative care
The area of resected pericardium was determined by measurement of the excised pericardium and ranged from 8 to 25 cm².

FIG 1. Kaplan–Meier survival analysis for 15 dogs undergoing thorascopic pericardial window for management of pericardial effusion were separated as idiopathic pericardial effusion (IPE) (n=10) or neoplasia-related PE (n=5). Dogs still alive or lost to follow-up were censored.
It subjectively appeared that the portion of excised pericardium contracted to a smaller size following extraction from the thoracic cavity and the visualised pericardial window expanded after removal of the portion of pericardium. The area of the surgically created pericardial window may therefore have been larger than the measured area of excised pericardium.

Thoracoscopic pericardial window was successfully completed in 14 dogs while one case required conversion to open surgery (see below). The median surgery time in these 14 dogs was 52.5 (range, 45-80) minutes.

Histopathology of the pericardium was performed in 11 cases; in the remaining 3 cases it was not requested. In all cases, there were inflammatory changes (lymphocytic, plasmacytic and neutrophilic infiltration). No evidence of neoplasia was noted in any sample. In one of these cases, the parietal pleura throughout the thoracic cavity had a slight opaque appearance and was biopsied. Histopathology revealed carcinomatous changes suggestive of mesothelioma. None of the cardiac masses were biopsied as access during thoracoscopy was limited and because of concerns that major haemorrhage would ensue post-biopsy. In addition, none of the masses were felt to be surgically resectable based on ultrasonographic examination.

Postoperative thoracic drains were placed in 12 of the 14 cases that successfully completed thoroscopic pericardial window. The drains were removed within 12 hours of surgery in nine cases because of minimal production of air or fluid, and in one further case to minimise decreases in intrathoracic pressure, that might have contributed to haemorrhage from a cardiac mass. Drains remained in place for 4 days after surgery in two cases. In two further cases, postoperative thoracic drains were not placed and thoracocentesis was performed to evacuate the pneumothorax after closure of the cannula sites. Opioid analgesia was only required for the first 24 hours post-surgery in all 14 cases. Non-steroidal anti-inflammatory drugs were given for no more than 5 days post-discharge. The median time to discharge from the hospital after thoracoscopic surgery was 1 day (range, 1-6).

Complications

Significant complications occurred during or after thoracoscopy in 4 of 15 dogs (26.7%). These included two dogs with idiopathic PE and two dogs with cardiac masses.

In one dog with idiopathic PE and the sixth in the series to undergo surgery, significant haemorrhage occurred from a mediastinal blood vessel during the initial sectioning of the ventral mediastinum. Unsuccessful attempts were made to control this haemorrhage with monopolar electrocoagulation and a decision was made to convert to open surgery via a median sternotomy. The mediastinal blood vessel was subsequently ligated and a partial pericardiectomy was performed in a standard open manner. Following this case, bipolar laparoscopic forceps were used for haemostasis of blood vessels within the ventral mediastinum and no further episodes of uncontrolled haemorrhage were noted in the remaining cases.

The other dog with idiopathic disease developed a mild subcutaneous seroma due to presumed leakage of fluid from the thoracic cavity and intercostal cannula sites. Thoracic drains had not been placed at the time of surgery. No treatment was necessary and the seromas resolved.

One dog with a cardiac mass developed significant haemorrhage into the thoracic cavity, within an hour of thoracoscopic surgery. There was no evidence of coagulopathy, chest drainage was stopped and supportive fluid therapy initiated. However, the dog was euthanased the following day because of persistent haemorrhage. The remaining dog developed suspected pulmonary thromboembolism during recovery. This presumptive diagnosis was based on the development of respiratory distress, hypoxia and hypocapnia. The dog recovered after treatment with dalteparin [80-150 IU/kg Fragmin; Pfizer, subcutaneously (sc) every 4-8 hours] and acetylsalicylic acid (0.5 mg/kg Aspirin; Bayer, orally every 12 hours) and was subsequently discharged 6 days after surgery.

Postoperative follow-up

Clinical signs of recurrent cardiac tamponade did not occur in any case. Of the nine dogs with idiopathic PE that completed thoracoscopic surgery, one is still alive at the time of writing (150 days after surgery), one was lost to follow-up at 180 days, and five were euthanased between 76 and 1095 days for apparently unrelated reasons including multicentric lymphoma (n=1), splenic mass (n=1) and un-investigated lethargy (n=3). The remaining two dogs were euthanased 638 and 1165 days after surgery, respectively, because of dyspnoea secondary to persistent pleural effusion. The five dogs with neoplasia-related PE were all euthanased between 1 and 107 days after surgery because of complications or progression directly relating to their illness. MTSIs in the idiopathic and neoplasia groups were 635 (range, 76-1165) and 30 (range, 1-107) days, respectively. The survival curves, assessed by the Mantel Cox method, were significantly different (P=0.0004). A hazard ratio of 5.37 (95% CI 5.49-1850) was determined.

DISCUSSION

In this study, thoracoscopic pericardial window was successfully completed as sole surgery in the majority (>90%) of dogs. It was associated with an acceptable complication rate (approximately 25%), low mortality (7%), rapid surgery (<1 hour) and relatively short hospitalisation times (one day). In addition, in most cases presented, the pre-surgical aim of chronically relieving the effects of the PE without the need for repeated pericardiocentesis or open surgery was achieved. To the authors’ knowledge this study includes one of the longest follow-up and largest number of cases undergoing thoracoscopic pericardial window thus far published.

A limitation of the study is the number of cases in which the PE had different and often only suspected causes. In addition, information was obtained from retrospective analysis of case records where each animal was managed individually rather than in a controlled manner. Finally, cases treated by an alternative surgical method were not available for direct comparison limiting definitive conclusions that can be made. Despite these limitations, the study group reflects the type and variety of cases presented to
veterinary surgeons where clinical and therapeutic decisions must be made in field conditions. In addition, minimally invasive techniques are a growing area of interest where additional data is required specifically regarding complications and outcome. A recently published study included a larger cohort of 36 dogs that underwent a similar thoracoscopic pericardial window procedure (Case et al. 2013). However, a paucity of information regarding surgical technique, short-term complications and hospitalisation times were included.

Other minimally invasive techniques, such as percutaneous balloon pericardiotomy, have previously been described (Cobb et al. 1996, Bussadori et al. 1998, Sidley et al. 2002). However, with such a technique direct visualisation or biopsy is not possible, and potential problems have been reported, such as closure of the stoma and recurrence of PE.

There are also other studies describing different approaches and techniques for thoracoscopic pericardiectomy (Jackson et al. 1999, Dupré et al. 2001, Mayhew et al. 2009). In these studies, lateral or paraxiphoid approaches with one-lung ventilation were used (Jackson et al. 1999; Mayhew et al. 2009). One-lung ventilation has been shown to detrimentally affect gas exchange and haemodynamic function at least experimentally (Kudnig et al. 2003). A paraxiphoid approach without one-lung ventilation has previously been used without specific complications (Dupré et al. 2001). A similar approach was used in this study without specific complications supporting the contention that this method is preferable as it avoids selected intubation, maintains bilateral lung function and is not technically demanding. Thoracoscopy may involve partial, or subphrenic pericardiectomy; in specific circumstances, such as constrictive pericarditis (Heinritz et al. 2005), a subphrenic pericardiectomy may be a preferable technique.

In controlled experimental studies, thoracoscopic pericardial window was considered to have several advantages over open partial pericardiectomy including decreased postoperative pain and more rapid return to function (Walsh et al. 1999). In this study, the hospitalisation times depended on the duration of drainage post-surgery, complications and degree of postoperative pain. However, hospitalisation times were short as thoracic drains could be removed in the majority of dogs on the same day as surgery. In addition, opioid analgesia was only required for the first 24 hours in all dogs corroborating the findings of another study (Vicari et al. 2001). This contrasts with a much shorter MST of 30 days in this study, more comparable to the MST of 2-7 days for neoplastic effusions as reported elsewhere (Case et al. 2013).

One-lung ventilation was also reported as a significant complication in another study (Weisse et al. 2001). Conversion to open thoracotomy was subsequently required. However, it is possible that this may have been avoided if bipolar rather than monopolar laparoscopic haemostatic forceps had been used as they were in all subsequent cases. Haemorrhage also occurred in one dog with a cardiac mass after thoracoscopy that was not associated with intraoperative complications but that was subsequently euthanased. It is possible that the cardiac tamponade present before pericardial window was preventing further haemorrhage from the mass. Once the pericardiectomy had been performed, on-going haemorrhage into the pleural space was potentially facilitated. To the authors’ knowledge, this complication after such a procedure has not been reported previously but should be considered in animals with compatible clinical signs. The remaining complication noted was a suspected pulmonary thromboembolism. This was not considered a complication specific to thoracoscopy but rather to the animal’s underlying condition and general surgical intervention. Cannula-site metastasis has also been reported as an adverse effect in a dog with an invasive mesothelioma causing pericardial and pleural effusion (Brison et al. 2006). In this case, metastasis to the cannula site may have been due to leakage of pleural/pericardial fluid into the cannula site, direct invasion from the pleural surface or possibly due to direct contamination while extracting biopsy samples and excised pericardial tissue through the cannula site. Although metastasis was not encountered in any of these cases over the limited follow-up period, there may be a risk of contamination of the cannula site with neoplastic cells, either due to pleural fluid leakage or on extraction of the excised portion of pericardium if the effusion was of neoplastic origin. Specimen-retrieval bags or wider cannulas were not used in this study, but their use could be a consideration on extraction of the excised pericardial tissue.

Of the five suspected neoplasia cases, four had detected cardiac masses and one had suspected mesothelioma. None had a prolonged survival with the longest being 107 days after thoracoscopy. In a previous study, the mean survival time of dogs with heart base masses that underwent pericardiectomy was significantly longer (661 ±170 days) than when treated medically (129 ±51 days) (Vicari et al. 2001). This contrasts with a much shorter MST of 30 days in this study, more comparable to the MST of 2-7 days for neoplastic effusions as reported elsewhere (Case et al. 2013). Direct comparisons between studies are, however, difficult because of the small number of cases, use of mean versus median values and lack of histopathological classification of tumour type. In a previous study (Weisse et al. 2005), dogs with right atrial haemangiosarcoma (confirmed by histopathology) that underwent peri-cardiectomy with resection of the tumour had a MST of 175 days with and 42 days without adjuvant chemotherapy. It is possible that the dogs of this current study also had haemangiosarcoma. It is also possible that surgical intervention was being considered as a last resort and at a later time in the course of the disease than in other studies. Regardless of this, neoplasia-related PE was associated with a much shorter survival time than for idiopathic PE and owners must be made aware of this when considering intervention for their pets. The longest surviving neoplasia case was the dog with mesothelioma. Prolonged MSTs of 13-6 months have been
described with mesothelioma (Dunning et al. 1998) but have also been suggested to be less than 120 days (Stepien et al. 2000).

From the 10 cases with suspected idiopathic PE in this study, 9 cases had survival times longer than 120 days. Only one case was euthanased earlier but this was for unrelated reasons 90 days after surgery. The MST of 685 days was significantly longer compared to that of neoplasia-related PE and exceeded previous reports of 13.1 months in a group of 12 dogs similarly treated (Case et al. 2013). Indeed, of those where outcome was known, the majority were euthanased for apparently unrelated reasons. Only two cases were euthanased for reasons related to the PE because of persistent pleural effusion. The origin of the effusion remains unclear but several potential explanations exist. It is possible that both had undetected mesothelioma. However, these cases had the longest survival times (638 and 1165 days) in excess of those previously reported (Dunning et al. 1998). It is also possible that the same inflammatory lesion affecting the pericardium was also affecting the pleural surface. Interestingly, a previous study suggested that golden retrievers with thoracic inflammation because of pleural effusion can develop pericardial mesothelioma (Machida et al. 2004). Unfortunately, postmortem examinations were not carried out in the two dogs of this study.

A recent study compared the outcome of thoracoscopic pericardial window to that of subtotal pericardectomy by thoracotomy for the treatment of PE in dogs (Case et al. 2013). Dogs with idiopathic PE that underwent the pericardial window technique had a significantly shorter MST (13.1 months) than did dogs treated by subtotal pericardectomy via thoracotomy (MST not reached during study) suggesting a superior long-term outcome for the latter technique. However, there were only five dogs included in the group that had subtotal pericardectomy. The results of this study demonstrate a longer MST (22 months), in comparison with group that had subtotal pericardiectomy. The results of this study demonstrate a longer MST (22 months), in comparison with the MST of 13.1 months in a group of 12 dogs similarly treated (Case et al. 2013). Indeed, of those where outcome was known, the majority were euthanased for apparently unrelated reasons. Only two cases were euthanased for reasons related to the PE because of persistent pleural effusion. The origin of the effusion remains unclear but several potential explanations exist. It is possible that both had undetected mesothelioma. However, these cases had the longest survival times (638 and 1165 days) in excess of those previously reported (Dunning et al. 1998). It is also possible that the same inflammatory lesion affecting the pericardium was also affecting the pleural surface. Interestingly, a previous study suggested that golden retrievers with thoracic inflammation because of pleural effusion can develop pericardial mesothelioma (Machida et al. 2004). Unfortunately, postmortem examinations were not carried out in the two dogs of this study.

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

References