Retrospective Evaluation of Clinical, Clinicopathological and Echocardiographic Findings Associated with Survival in 108 Dogs with Cardiac Tamponade

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ABSTRACT

The objective of this study was to characterize the clinical, laboratory and echocardiographic findings of dogs with cardiac tamponade and their prognostic value. Medical records of 108 dogs undergoing pericardiocentesis were reviewed. The median survival time was 44 days (range 0.5 - 1455). Males were over-represented ($P = 0.03$). Mixed-breed dogs were under-represented ($P = 0.003$), while Golden retrievers were over-represented ($P = 0.01$). The latter were significantly ($P = 0.004$) more likely to have "echo-negative" cardiac tamponade. Factors significantly ($P \leq 0.02$) and positively associated with 30 day survival included an ability to ambulate or ascites at presentation, presentation to and pericardiocentesis performed by the Cardiology Service, normal femoral pulse intensity, longer inter-pericardiocentesis intervals and undergoing pericardectomy. Thirty-day survival and complication rates were not associated with the pericardiocentesis approach (i.e., choosing the right vs. the left hemithorax, $P = 0.17$). The pericardial fluid volume drained correlated positively and significantly ($r = 0.77$; $P < 0.0001$) with the echocardiographically measured apex-to-pericardial distance: on average, for every 1 cm measured, 125 mL of pericardial fluid was drained. Dogs presenting with cardiac tamponade had a poor long-term prognosis; however, Golden retrievers, non-pale, ambulatory and ascetic dogs, dogs selected for pericardectomy and those with longer inter-centesis intervals had a longer median survival time. The hemithorax from which pericardiocentesis was performed did not affect survival or complication rates.

Keywords: Pericardial Effusion; Cardiac Mass; Echocardiography; Pericardiocentesis; Pericardectomy.

INTRODUCTION

Pericardial effusion (PE) is the accumulation of free fluid between the visceral and parietal layers of the pericardial sac. Regardless of the effusate volume (which often depends on rate and chronicity of accumulation), as long as intra-pericardial pressure remains low, the effusion does not trigger cardiac tamponade. Cardiac tamponade, however, does result from a rise in intra-pericardial pressure to values exceeding those of the intra-cardiac diastolic pressure. This, in turn, will trigger a hemodynamic compromise due to a decrease in preload, with a resultant decrease in cardiac output and in coronary perfusion, and is therefore considered a life threatening emergency (1). The prevalence of cardiac tamponade in dogs was estimated at 1/233 cases (0.42%)

in one veterinary referral hospital (2). Cardiac tamponade might develop due to various etiologies, most commonly neoplastic or "echo-negative" (i.e., demonstrating no echocardiographic evidence of a solid mass near or in the heart or pericardial sac). Left atrial rupture associated with degenerative mitral valve disease involving full-thickness jet lesions, infectious pericarditis and anticoagulant rodenticide toxicity are considered less common etiologies (1). Despite some discrepancies between previous studies of PE, neoplastic disorders were the most common (58% to 61% of cases) underlying etiologies (2, 3). Among these, the most commonly reported are right-atrial hemangiosarcoma ((HSA), 60% to 75% of tamponade-causing neoplasms) and heart base tumors (HBT) (8% to 10% of all cardiac neoplasms) (1, 3). Less commonly reported, and likely underdaignosed, are non-solid neoplasms such as mesothelioma.

Pericardiocentesis (PC) is an effective emergency treatment for life-threatening cardiac tamponade (4). Although PC is commonly performed, and a right hemithorax approach has been suggested to have advantages over a left-sided one (3, 4), to the best of our knowledge, this suggestion has never been substantiated.

Echocardiography is considered the "gold standard" modality for identifying pericardial masses (4) with a reported sensitivity and specificity of 82 and 100, 82 and 99, and 74 and 98%, for detecting cardiac masses, right-atrial masses, and heart base tumors, respectively (2).

Surgical pericardectomy is usually reserved for recurrent PE, and is done by subtotal pericardectomy via lateral thoracotomy or median sternotomy, or by window pericardectomy via thoracoscopy. In dogs with suspected cardiac neoplasia, surgery might provide diagnostic confirmation, and is typically palliative rather than curative. The median survival time (MST) of dogs with cardiac HSA undergoing mass excision followed by chemotherapy was 140-174 days (5, 6). The prognosis for cardiac tamponade due to PE varies considerably, depending on the underlying cause. The MST ranges from one-to-6 months for dogs with non-surgical HSA, while prognosis can be more favorable in patients with HBT or with "echo-negative" effusions (7, 8, 9, 10).

The aims of this study were to 1) characterize, clinical and laboratory findings, treatment, and prognosis in a large cohort of dogs with cardiac tamponade presented to a tertiary referral hospital; 2) to identify factors associated with their short- and long-term outcomes; 3) to determine if the approach of the PC (i.e., through the right vs. the left hemithorax) was associated with complications and the outcomes.

Our hypothesis was that certain clinical, laboratory and imaging findings at presentation had a prognostic value in dogs with cardiac tamponade.

MATERIALS AND METHODS

Animals, data collection and definitions

A retrospective electronic search was conducted to identify all dogs that had had undergone pericardiocentesis, either at the Emergency Services or at the Cardiology Service between December 2006 and September 2011. Dogs with incomplete medical records and dogs with peritoneal pericardial diaphragmatic hernia were excluded. Data were collected from the medical records, including the signalment, physical examination, echocardiographic and laboratory findings at presentation.

Echocardiography was performed by a board-certified cardiologist or a supervised cardiology resident using a 7S (3.1-8.0 MHz) or a 3S (1.5-3.6 MHz) phased array transducer (Vivid 3, General Electric, Tirat-Carmel, Israel). Images were obtained using standard bilateral views. In each case, data of the PC procedure were collected (i.e., the hemithorax chosen for the PC approach, the aspirated fluid volume, the total cumulative number of PCs performed and the interval between recurrent PCs). The occurrence and nature of complications were also recorded. Heart rate, respiratory rate, rectal temperature, oscillometric blood pressure measurements (Cardell Ltd., Model 9401, CAS Medical Systems, Branford, CT), packed cell volume (PCV) and total protein (TP) prior to, and following the PC, were recorded. Echocardiographic measurements both prior to and following PC were recorded. They included 2-dimensioanl, M-mode, colour and spectral Doppler systolic and diastolic variables, evidence of cardiac masses (including location, dimensions and subjectively assessed echogenicity), and the maximal apex-to-pericardial distance as measured from the left, parasternal, apical four-chamber view (as a linear measure assisting subjective assessment of effusate volume) at the first echocardiographic evaluation. Final echocardiographic diagnosis and surgical intervention (i.e., type of pericardectomy and complications), surgical diagnosis, and duration of hospitalization were documented as well.

Tentative first presentation-related echocardiographic diagnoses of the causes for PE were retrospectively and broadly divided into idiopathic (namely "echo-negative"), suspected HSA (based on right-atrial location and small mass dimensions), suspected HBT (based on peri-aortic arch location and relatively large mass dimensions), or suspected as mitral jet-lesion related. As histopathology and cytological reports were available for only 13 and 14 dogs, respectively, these data were not included in the study.

Dogs alive after 30 days following the first pericardiocentesis were defined as short-term survivors. The Mean survival time (MST) was established based on information retrieved from the medical records and from a follow-up telephone interview with the owners. The information retrieved from owners included the dogs' status (i.e., alive, dead or having been euthanatized), date of death or euthanasia, time from discharge to death, and the major clinical signs presented by the dog prior to death.

Pericardiocentesis

Ultrasound-guided PC was performed either by the Cardiology Service (from the left hemithorax while the dog was in right lateral recumbency, at an angle parallel to the anatomical cardiac axis, aiming from the left cardiac apex towards the right heart base), or by the Emergency Service (from the left or right hemithorax, depending on the attending clinician's preference, either along the same axis or at the fifth to sixth costochondral junction level). The procedure was performed using a 14-to-18g over-the-needle catheter, depending on the dog's size, under aseptic conditions, while monitoring the ECG for heart rate changes and transient, "mechanical" (catheter-epicardial-contact related) occurrence of arrhythmia.

Statistical analysis

The distribution pattern of continuous parameters was assessed using the Shapiro-Wilk test. Normal and non-normal distributed continuous parameters were compared between two groups using the Student's *t* or Mann-Whitney *U*-tests, respectively. Fisher's exact or chi-square tests were used to compare categorical variables between groups. The association between categorical variables and 30-day survival, as well as MST, was examined using the Kaplan-Meier product limit method and the log-rank test. Correlations between continuous parameters were examined using the Pearson or Spearman's rank correlation tests, for normally and non-normally distributed parameters, respectively. All tests were two-tailed, and a $P \leq 0.05$ was considered statistically significant. All calculations were performed using statistical software (SPSS® for Windows®, SPSS Inc., Chicago, IL, USA).

RESULTS

Demographic data

The electronic database search identified 109 dogs that had undergone PC due to cardiac tamponade, of which one with an incomplete medical record was excluded. Compared to the general teaching hospital population, the prevalence of PC due to cardiac tamponade was 1 in 265 dogs (0.4%). The study included 70 males (65%; 50 intact, 71%) and 38 females (35%; 5 intact, 13%). Males were significantly ($P = 0.03$) over-represented. The median age and body weight were 10.5 years (range 0.3 to 17.2 years) and 29.1 kg (range 8.0 to 55.0 kg), respectively. The age and body weight were not associated with survival. Compared with the general hospital population, mixed breed dogs were under-represented (45% vs. 58%, $P = 0.003$), while Golden retrievers were over-represented (14% vs. 6%, $P = 0.01$). Boxer (n = 7) and German shepherd (n = 4) dogs were the next most prevalent breeds, but were not overrepresented. For all other breeds, low numbers precluded similar statistical comparisons.

Clinical and laboratory findings at presentation

The most common clinical signs at presentation included weakness (58 dogs, 53%), anorexia (53 dogs, 49%), increased respiratory effort (52 dogs, 48%), ascites (51 dogs, 47%), muffled heart sounds (51 dogs, 47%) and tachycardia (heart rate >160 bpm; 44 dogs, 47%). Ascites and weakness were significantly more common in survivors compared to non-survivors (31 dogs; 28% vs. 20 dogs; 18%; $P = 0.01$, and 33 dogs; 30%; vs. 25 dogs; 23%; $P = 0.03$, respectively). Pallor, weak femoral pulses and inability to ambulate were significantly more common in non-survivors compared to survivors (seven dogs; 6% vs. zero dogs; $P = 0.01$; 23 dogs; 21% vs. seven dogs; 6%; $P = 0.002$ and 19 dogs; 17%; vs. eight dogs; 7%; $P = 0.04$, respectively) (Tables 1 and 2). Twenty seven percent of the dogs in this study presented with emesis showing no intergroup differences.

The median PCV prior to the third PC was significantly ($P = 0.03$) lower in the non-survivors compared to the survivors (29.5% vs. 35.0%, respectively).

Pericardiocentesis

Pericardiocentesis was performed only once in 46 dogs. The first PC was performed by the Cardiology Service in 36 dogs, by the Emergency Service in 45 dogs (Table 2), and by referring veterinarians, prior to presentation, in 11 dogs, while in the remaining 16 the receiving service was not recorded. The maximum number of PCs performed in a single dog was nine. The survival rate (both 30 days and MST) did not differ between dogs undergoing a single PC compared to those undergoing several procedures ($P = 0.6$). However, the time intervals from the first to second and from the second to third PCs were significantly longer in survivors compared to non-survivors (31 vs. 17 days and 19 vs. 10 days; $P = 0.001$, and $P = 0.04$, respectively; Table 3).

The volume of the drained pericardial fluid in the first PC (n = 31) correlated positively and significantly ($r = 0.77$; $P < 0.0001$) with the echocardiographically measured apex-to-pericardial distance prior to the first PC. On average, for every 1 cm of effusate measured from apex-to-pericardium, 125 mL of pericardial fluid was drained. There was no association between apex-to-pericardial distance or volume of fluid drained by PC and the 30-day survival ($P = 0.086$ and 0.500, respectively).

Echocardiographic diagnoses

A complete echocardiographic examination was performed in 88/108 dogs. Tentative echocardiographic diagnoses of the PE were retrospectively and broadly divided into "echo-negative" (49 dogs, 56%), suspected HSA (24, 27%), suspected HBT (8, 9%) or mitral insufficiency related (7, 8%). Dogs with "echo-negative" cardiac tamponade had a significantly longer MST compared to all other disease groups combined (92 vs. 18 days, $P = 0.005$; Table 4, Figure 1A). "Echo-negative" cardiac tamponade was significantly more common in Golden retriever dogs compared to other breeds ($P = 0.004$). The 30-day survival time was significantly ($P = 0.05$) shorter in dogs in which intra-pericardial masses were detected by echocardiography, whether subjectively assessed as HAS or HBT (n = 32), compared to other dogs.

Of seven dogs with severe, degenerative mitral valve dis-

Table 1: Clinical signs upon presentation in 108 dogs presenting with cardiac tamponade. Statistically significant differences between survivors and non-survivors are denoted in bold.

Clinical sign	All dogs (n=108)	Survivors (n=51)	Non-survivors (n=57)	*P*-value
	Number (%)	Number (%)	Number (%)	
Weakness	**58 (53.7)**	**33 (56.8)**	**25 (43.2)**	**0.035**
Anorexia	53(49.1)	27 (50.9)	26 (49.1)	0.560
Increased respiratory effort (dyspnea)	52 (48.1)	22 (42.3)	30 (57.7)	0.340
Ascites	**51 (47.2)**	**31 (60.7)**	**20 (39.3)**	**0.012**
Muffled heart sounds	51 (47.2)	20 (39.2)	31 (60.8)	0.127
Tachycardia (HR>140/min)	44 (40.7)	18 (40.9)	26 (59.1)	0.330
Paradoxical pulsation	35 (32.5)	15 (42.8)	20(57.2)	0.540
Tachypnoea	34 (31.5)	19 (55.8)	15 (44.2)	0.300
Collapse	32 (29.6)	17 (53.1)	15 (46.9)	0.530
Pallor	**30 (27.7)**	**7 (23.3)**	**23 (76.7)**	**0.002**
Vomiting	29 (26.9)	11 (37.9)	18 (62.1)	0.280
Weak femoral pulse	**27 (25.0)**	**8 (29.6)**	**19 (70.4)**	**0.045**
Cough	24 (22.2)	15 (65.5)	9 (34.5)	0.110
Diarrhoea	21(19.4)	9 (42.8)	12 (57.2)	0.810
Cyanosis	11 (10.2)	5 (45.4)	6 (54.6)	1.000
Cachexia or sarcopenia	9 (8.3)	3 (33.3)	6 (66.6)	0.500
Non ambulatory	**7 (6.5)**	**0**	**7 (100)**	**0.014**
Organomegaly	5 (4.6)	3 (60.0)	2 (40.0)	0.670
Crackles	5 (4.6)	3 (60.0)	2 (40.0)	0.450

ease with a high left ventricular to left atrial systolic pressure gradient, four were suspected (although not definitively proven by necropsy or supported by echocardiographic evidence of intrapericardial clots) to have had a secondarily ruptured left atrial free wall, leading to acute, haemorrhagic cardiac tamponade. In the remaining three, the pericardial effusate was assessed as a modified transudate, and its development was attributed to chronic, bilateral congestive heart failure. This group consisted of four Dachshunds, two mixed breed dogs, and one Beagle dog. Three of the four Dachshunds had a suspected acute left atrial wall rupture.

Complications

Pericardiocentesis related complications were recorded in 10 dogs (8.3%): in six, the pericardial effusate could not be completely drained, and pleural effusion developed, while in one, a cardiac chamber was unintentionally penetrated (based on rapid clot formation of drained intracardiac blood in an activated clotting time tube containing diatomaceous earth) with no apparent consequences. Three dogs experienced cardiac arrest during or shortly after PC. Of the latter three, one with chronic valvular heart disease was presented due to acute collapse and was suspected to have developed a ruptured left atrial free wall. One dog developed an acute re-accumulation of haemorrhagic PE after completing the first PC and died during the next PC. This dog was tentatively diagnosed with HSA based on echocardiography. The last dog re-presented a few hours post PC in cardiac arrest.

Survival analysis

Telephone interviews were made with 98 of patient owners. Eight dogs were alive at follow-up, at 1 to 45 months after the initial PC. Both the MST and the 30-day survival were significantly shorter in dogs unable to ambulate at presentation ($P < 0.001$ & $P = 0.01$, respectively). Those presented with pallor ($P = 0.001$ & 0.002, respectively) or with (sus-

Table 2: Summary of factors significantly associated with median survival time and with 30-day survival in 108 dogs presenting with cardiac tamponade.

Parameter		Number of dogs	Median survival time (MST)			MST P-value	30 day survival P-value
			Median (days)	95% CI (days) min	95% CI (days) max		
Clinical signs on presentation							
Ascites	Yes	47	124	30	218	0.004	0.01
	No	54	14	7	21		
Weakness	Yes	55	84	33	135	0.2	0.04
	No	46	18	4	32		
Pale mucous membranes	Yes	29	11	4	18	0.001	0.002
	No	72	54	28	80		
Ambulation	Yes	101	47	16	78	<0.001	0.01
	No	7	3	0	6		
Weak femoral pulses	Yes	24	15	5	25	0.99	0.05
	No	77	52	5	25		
Pericardiocentesis							
Service performing PC	ECC	45	14	7	21	0.1	0.02
	Cardio	36	63	28	98		
PC hemithorax of choice	Right	35	19	0	56	0.18	0.17
	Left	37	63	12	114		
Echocardiography and surgery							
Suspected or confirmed Neoplasia	Yes	39	19	12	26	0.001	0.02
	No	59	90	29	151		
Surgery	Yes	26	121	11	231	0.01	0.006
	No	77	17	7	27		

Cardio, Cardiology; ECC, Emergency Critical Care; MST, median survival time; PC, pericardiocentesis. 95% CI: 95% Confidence Interval

pected or confirmed) intra-pericardial masses ($P = 0.001$ & 0.02, respectively), had a significantly shorter survival than dogs presented without these findings. Similarly, those presented with ascites ($P = 0.004$ & 0.01, respectively) or that had received surgical pericardectomy ($P = 0.01$ & 0.006, respectively) had a significantly longer survival than those presented with no ascites or those receiving no surgery, respectively (Table 2; Figures 1B-1F).

Dogs presenting with adequate femoral arterial pulses, and those in which the Cardiology Service performed the first PC had higher 30-day survival rates compared to those presenting with weak femoral pulsation and those in which the Emergency Service performed the first PC. However, these factors were not associated with the longer-term MST (Table 2).

The approach of the PC procedure was recorded in 72 dogs. Right and left hemithorax approaches were made in 35 dogs (48.6%) and 37 dogs (51.4%), respectively. The approach was not associated with the 30-day survival rate, the longer-term MST or the complication rate (Table 2). The 30-day or longer-term MSTs were not associated with a documented paradoxical pulse at presentation, body temperature, heart and respiratory rates upon presentation, or systolic blood pressure abnormalities prior to or following PC.

Pericardectomy was performed in 26 dogs (23%), by thoracoscopy (eight dogs), lateral thoracotomy (nine dogs)

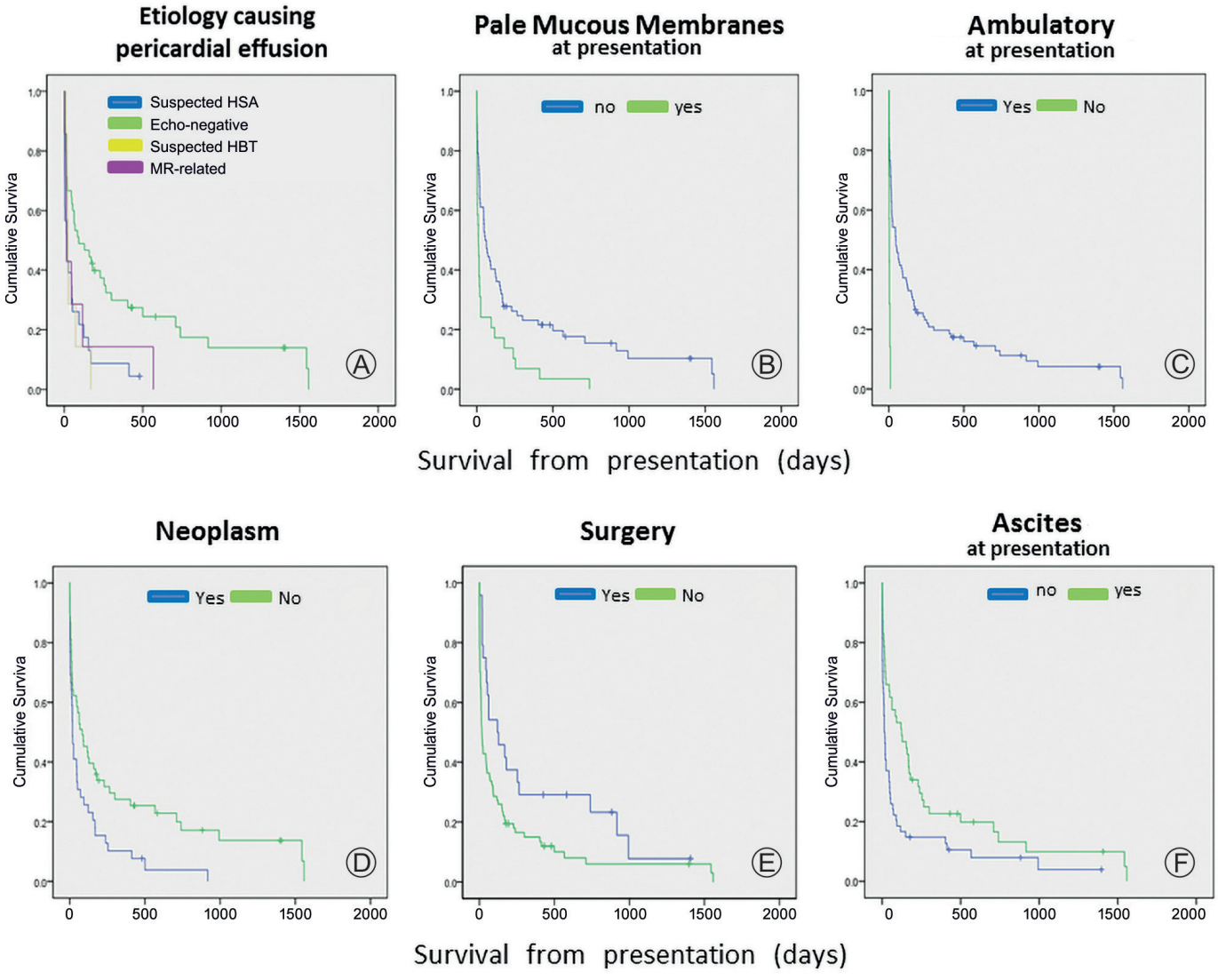

Figure 1(A-F): Kaplan-Meier curves of factors associated with cumulateive survival in 108 dogs with cardiac tamponade.
MR: Mitral regurgitation.

and median sternotomy (nine dogs), with no 30-day survival rate or MST differences among these subgroups. However, both the 30-day survival rate and the MST were significantly higher in dogs undergoing pericardectomy compared to dogs which were not selected for pericardectomy ($P = 0.006$ and $P = 0.01$, respectively; Table 2).

DISCUSSION

This study evaluated multiple findings in 108 dogs presented to a tertiary referral centre with PE and cardiac tamponade and their association with 30-day survival and with the MST. Most parameters that were significantly associated with the 30-day survival were also significantly associated with the MST, most likely because the MST of the entire cohort was not much longer than 30 days (44 days).

Dogs that were "echo-positive" for a mass had a significantly shorter 30-day survival rate than "echo-negative" dogs, which also had a significantly longer MST compared to all other dogs combined (i.e. suspected HSA, suspected HBT, or suspected mitral regurgitation related atrial rupture). The MST of the "echo-negative" group was, nevertheless, relatively short (three months). In the present study, 56% of the dogs that underwent complete echocardiography were "echo-negative", while in contrast, in three previous studies, neoplasia was the most common aetiology of cardiac tamponade occurring in 58%, 61% and 56% of the dogs (2, 3, 11). Considering the short MST in this study, it is plausible that some dogs with recurrent "echo-negative" cardiac tamponade were euthanized due to financial constrains leading the owners to decline pericardectomy. Secondly, some of the dogs with "echo-negative" cardiac tamponade may have had small, undetectable masses, which are typical for HSA, or they could have had mesothelioma which went undetected. As Golden retriever dogs were more likely to have "echo-negative" cardiac tamponade, surgical intervention should be more favorably considered for dogs of this breed if cardiac tamponade recurs and a mass is not detected. However, this specific breed has also been suspected as predisposed to the development of pericardial mesothelioma following a chronic inflammatory process associated with idiopathic haemorrhagic PE (12). Such natural history could not be definitively ruled out in Golden retriever dogs reported in the present study, and might explain both their being "echo-negative" and their potential contribution to the relatively short MST in the entire cohort.

Table 3: Time interval (days) between the first and second, and between the second and third pericardiocentesis procedures in 77 dogs with cardiac tamponade, and its association with survival.

PC interval	Survivors		Non-survivors		*P* – value
	N	Median (range)	N	Median (range)	
1st-2nd interval	31	35 days (0-1245)	17	9 days (1-365)	0.001
2nd-3rd interval	19	21 days (1-289)	10	5 days (1-131)	0.04

PC, pericardiocentesis

Table 4: Median survival time and suspected aetiology in 88 dogs with cardiac tamponade (CT) that have undergone echocardiography.

Suspected Aetiology for CT	Total Number of Dogs (%)	Survivors		*P* – value
		Number of Dogs (%)	Median Survival Time in Days (range)	
HSA	24 (27)	9 (38)	17 (0-39)	0.005*
HBT	8 (9)	2 (25)	24 (14-34)	
"Echo-negative"	49 (56)	30 (61)	92 (0-218)	
MR	7 (8)	3 (43)	14 (9-19)	
Total	88	44 (50%)		

* The P value denotes the survival difference between the echo-negative group and all other groups.
"Echo-negative", having no echocardiographically identified evidence of an intra-cardiac or peri-cardiac mass;
HBT, echocardiographically suspected heart base tumour; HSA, echocardiographically suspected hemangiosarcoma;
MR, echocardiographically suspected left atrial rupture due to a mitral regurgitation related, full thickness jet lesion

Longer time intervals between the first to second, and second to third PCs were associated with longer MSTs. To our knowledge, such associations have not been previously reported. These are not surprising, since shorter time intervals between PCs most likely represent more severe underlying diseases, in which PE accumulates more acutely, developing intrapericardial pressure values that more rapidly compromise pericardial compliance. This results in earlier higher intrapericardial pressure, thereby lowering venous return, cardiac output and myocardial perfusion pressure. (1).

This study is also the first to associate apex to pericardial distance with volume of fluid drained during PC. This information may be valuable to clinicians when attempting to estimate the amount of fluid expected to be drained based on the initial ultrasonographic examination of the PE.

In the present study, dogs that underwent pericardectomy of any kind, in order to permanently relieve cardiac tamponade, had a significantly longer MST compared to those that did not (231 vs. 27 days, respectively, $P = 0.01$). This was probably partly because surgical intervention is mostly offered for dogs with echo-negative PE, and not for cases of suspected malignant or mitral regurgitation related left atrial rupture. This is in agreement with previous large cohort studies of PE in dogs (2, 3)

In this study, ascites was positively associated with both 30-day-survival and with a longer MST, as previously reported (3). Ascites typically reflects a chronic condition, more likely to be idiopathic or the result of a HBT, where the pericardial sac may have a longer window of opportunity to stretch and therefore maintains a higher level of compliance resulting in a relatively lower intra-pericardial pressure, thereby enabling better venous return and consequently, a relatively higher cardiac output.

As twenty seven percent of the dogs in this study presented with vomiting, a clinical sign that has been associated with cardiac tamponade, presumably involving either phrenic nerve mediated stimulation of the nucleus tractus solitarius, and/or gastrointestinal hypoperfusion with resultant elevation of serum lactate concentrations (13, 14). Regardless of the presumptive mechanism leading to vomiting, emesis should not preclude PE as a differential diagnosis (14).

Dogs presented to the Cardiology Service with PE had a better 30-day survival rate compared to those presented to the Emergency Service. There was no MST difference between these two groups, however. Dogs that electively presented to the Cardiology Service may have developed a more chronic, and therefore a more hemodynamically stable cardiac tamponade, compared to those urgently presenting as an emergency. Greater experience of the cardiologists compared to that of (sometimes-junior) clinicians operating during night shifts in the Emergency Service might have also played a role in this difference. The technical differences in the PC method between the services may provide another explanation. When approached from the left, the PC catheter penetrates the pericardial sac more ventrally, perhaps allowing for post-centesis passive drainage of any residual volume into the pleural space, once the patient is again ambulatory. This theory, however, remains to be specifically tested.

Previous studies have suggested an advantage in performing PC by a right hemithorax approach (3, 4). This is considered safer, since the thorax is penetrated via the pulmonary notch, minimizing the risk of pneumothorax, while also avoiding the two major epicardial coronary arteries located over the left heart in most dogs, whereas only one is located over the right epicardium. Conversely, in cases of right-atrial HSA, a right hemithorax PC may lacerate the mass and trigger more haemorrhage (1). In addition, should intra-ventricular cavities be inadvertently penetrated, the left-ventricular, highly pressurized and relatively more oxygenated blood should be more readily and promptly recognized and differentiated from intra-pericardial haemorrhagic effusate, than is expected when the right ventricular cavity is inadvertently penetrated. This may prove important where ultrasound-guidance is not available or when PC has to be performed by a single individual without assistance.

In this study, and in contrast to dogma, no differences in complication or survival rates following pericardiocentesis from the right versus the left hemithorax were noted. Nevertheless, as ultrasound guidance is now commonly available, it should preferably dictate the hemithorax from which PC is to be performed, whenever possible. Ultimately, such choices are to be tailored to each patient and made on a case-by-case basis.

Left atrial rupture due to mitral regurgitation related full thickness jet lesions is a sporadic cause of cardiac tamponade in dogs (15, 16). In the present study, seven dogs (8%) underwent PC due to cardiac tamponade secondary to mitral regurgitation, of which four were Dachshund dogs, and in three of these Dachshunds, ruptured left atrial walls were suspected shortly prior to PC. While this small subgroup pre-

cludes statistical analysis or drawing robust conclusions, this finding warrants further investigation to determine whether Dachshunds may have a higher tendency to experience a split left atrial free wall as a secondary complication of chronic mitral valve regurgitation.

Limitations of this study are mainly related to its retrospective nature. Important data such as complications, inadvertent penetration of cardiac chambers, life threatening arrhythmia during PC and other pertinent information may have been overlooked and not recorded appropriately in the medical records. The lack of histopathologic or cytological evidence regarding causes for effusion for most of the dogs in the study is another major limitation. Owner telephone reports regarding dates of death by which MSTs have been calculated could also be a potential limitation as they could have often depended on memory rather than on accurate date documentation.

In conclusion, dogs presenting for PE with cardiac tamponade have an overall poor prognosis; however Golden retriever dogs and ambulatory dogs presenting with ascites as opposed to collapse or pallor, and those without an echocardiographically detected mass, have a more favourable prognosis. Dogs selected for surgical procedures and those with a longer inter-centesis interval are more likely to survive. Complication and survival rates are not affected by the hemithorax from which PC is performed.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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