P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com
Research Article https://doi.org/10.47278/journal.ijvs/2022.132

Acquired Cardiac Diseases in 72 Dogs: A Prospective Study [2017-2020]

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Article History: 21-449 Received: 28-Nov-21 Revised: 25-Dec-21 Accepted: 17-Jan-22

ABSTRACT

Although canine cardiac diseases are an important health problem worldwide, limited records document their prevalence in Egypt. Cardiac diseases may be of acquired or congenital origin. A prospective study was designed to report the prevalence of cardiac diseases in a population of client-owned dogs. Clinical, radiographic, electrocardiographic, echocardiographic, and laboratory examinations were used to diagnose cardiac diseases. Cases were categorized according to the type of cardiac affection and the distribution. Demographic and biochemical data were statistically analyzed and expressed as mean and standard deviation (SD). The study population consisted of twenty different breeds, with the Griffon (n=20) and German shepherd dogs (GSDs) (n=14) the most affected groups. The male population (61.1%) was predominant in the affected breeds. The myxomatous mitral valve disease (MMVD) (48.6%) and dilated cardiomyopathy (DCM) (16.7%) formed a considerable population of the acquired affections. In conclusion, acquired cardiac affections showed only minor differences from previous geographical surveys. MMVD and DCM represent the most acquired cardiac diseases in the canine population.

Key words: Cardiac diseases, Canine, Distribution, Diagnosis

INTRODUCTION

Canine cardiac diseases represent a great challenge to veterinary practitioners all over the world (Hoque et al. 2019) contributing to approximately 8% of mortalities in companion animal (Egenvall et al. 2006). It has been estimated that approximately 10-15% of dogs presented to veterinary practices have cardiac diseases (Atkins et al. 2009; Hoque et al. 2019). Cardiac diseases may be either congenital or acquired with the latter constituting 95% of cardiac diseases. They could be categorized according to their origin into valvular, myocardial and pericardial diseases (Aiello 2016; Hoque et al. 2019).

Primary valvular diseases represent the most common acquired cardiac disease of dogs in many parts of the world (75%) (Fox 2012; Keene et al. 2019). They are better described as myxomatous mitral valve disease (MMVD) or chronic valvular cardiac disease, by mostly causing degenerative lesions for the mitral valve (Chan et al. 2019; Keene et al. 2019).

Dilated cardiomyopathy (DCM) is the most commonly diagnosed acquired myocardial disease of unknown etiology (idiopathic) in dogs (Vollmar et al. 2019). It is the second most prevalent cardiac disease (8% of the canine population) after MMVD leading to ventricular wall dilatation and systolic dysfunction (MacPete 2018; Dutton and López-Alvarez 2018). Additionally, DCM-like phenotypes may be contemporaneously identified with systemic illnesses, leading to a dilated heart of poor functionality (Beier et al. 2015). Myocarditis and systemic diseases such as hypothyroidism, nutritional deficiencies and toxicity were found to be predisposing to these phenotypes (Perego et al. 2012; Beier et al. 2015; Lakhdhir et al. 2020).

Although hypertrophic cardiomyopathy (HCM) is a relatively rare myocardial disease in dogs, HCM-like phenotypes, characterized by concentric left ventricular hypertrophy (LVH), may be also detected in association with systemic or cardiac abnormalities (Smith et al. 2015). Hyperthyroidism, hyperadrenocorticism (Cushing's syndrome) (Smith et al. 2015), systemic hypertension (Acierno et al. 2020), pressure overload due to left ventricular outflow tract obstruction in case of subaortic stenosis (SAS) were found to predispose to LVH (Yoon et al. 2015). Additionally, LVH detected secondary to sustained systemic hypertension is more accurately termed

Cite This Article as: Elsharkawy SH, Torad FA-S, Abu-Aita NA, Abdel-Ghany AK and EL-hussieny IN, 2022. Acquired cardiac diseases in 72 dogs: A prospective study [2017-2020]. International Journal of Veterinary Science 11(4): 427-434. https://doi.org/10.47278/journal.ijvs/2022.132

as hypertensive cardiomyopathy (HTN-CM) (Yoon et al. 2015; Acierno et al. 2020; Elsharkawy and Torad 2021). Chronic kidney disease can lead to sustained systemic hypertension and LVH. This phenomenon is commonly described as cardiovascular-renal axis disorder (CvRDk), specifically when primary kidney failure exists (Orvalho and Cowgill 2017).

Recently, pericardial disorders are more frequently presented in the canine patients by comprising approximately 8% of cardiac diseases (Tobias 2010; Bode 2019). They can manifest from stable pericardial effusion to more clinically significant cardiac tamponade (Pepi and Muratori 2006; Bode 2019) with pericardial effusion (PE) being the most commonly presented disorder (Tobias 2010).

Cardiac tumors are uncommon in the canine patients ranging between 0.12 and 4.33%. Hemangiosarcoma (HSA), aortic body tumors as well as lymphoma are the commonly detected cardiac neoplasms (Treggiari et al. 2017).

Various diagnostic tools are employed to reach an accurate diagnosis of the cardiac patients (Hoque et al. 2019). Echocardiography is accepted as a valuable non-invasive diagnostic tool for investigating cardiac diseases, however, clinical, radiographic, electrocardiographic examination along with serum biochemical analyses play an integral role for thorough cardiac examination (Boon 2011; Hoque et al. 2019).

Despite the extensive research and diagnosis of cardiac diseases worldwide, still there are no available records documenting the prevalent cardiac diseases among dog population admitted to clinical practice in Egypt. The aim of the present study was to record the incidence of cardiac diseases in dog practice in Egypt compared to previously recorded worldwide reports.

MATERIALS AND METHODS

Animals

A prospective study was designed to document cardiac diseases in client-owned dog population in Egypt. Dogs included in the study were admitted to the clinic of the Department of Surgery, Anaesthesiology and Radiology – Faculty of Veterinary Medicine- Cairo University (the largest dog clinic in Egypt) and private veterinary clinics in Cairo between January 2017 and December 2020. Dogs included in the study were diagnosed with cardiac disease either as an initial presentation or during routine clinical examination. Historical data were recorded for all dogs including dog breed, age, sex, body weight as well as associated clinical signs. Diagnosis of cardiac diseases was made through clinical, echocardiographic, electrocardiographic, radiographic as well as hematologic examination. All study procedures were approved by the Institutional Animal Care and Use Ethical committee of Faculty of Veterinary Medicine- Cairo University. Dog's owners were aware that their dogs will be used for research purposes and signed a consent indicating their approval.

Clinical Investigations

Echocardiography was performed as per standard recommendations (Cornell et al. 2004; Boon 2011). Right parasternal long axis (RPLA) and right parasternal short axis views (RPSA) views were both used for qualitative examination. B-mode and M-mode measurements were obtained from stored cine loops of three consecutive cardiac cycles in systole and diastole. Color flow Doppler was used to investigate the presence of any valvular insufficiencies or ventricular outflow tract obstruction. Cardiac dimensions and indices were compared to breed/ weight specific reference ranges (Boon 2011; Cornell et al. 2004; Visser et al. 2019). Standard right lateral thoracic radiographs were obtained at full inspiration using a film of (0.2x30x40 cm) dimensions at settings of 40-70 KVp and 3mAs with a focal film distance of 70-90 cm (Johnson et al. 2008). Standard six-limb lead ECG was recorded for each dog using a single channel ECG machine (Yasen, ECG 901A, China), where the alligator clips were placed as described before (Stern et al. 2013). The six standard limb leads I, II, III, aVR, aVL and aVF were recorded at paper settings of 10mm/mV and 50 mm/s with filter band settings of 0.05-150 Hz. Electrocardiographic parameters were evaluated and compared to previously established values for dogs (Stern et al. 2013).

Whole blood samples were withdrawn from the cephalic vein and were collected into EDTA and plain tubes for laboratory diagnosis using Biomerieux S.A. equipment (Marcy l' etoile, France) following the manufacturer's guidelines. Serum cardiac biomarkers (cardiac troponin I (cTnI), creatine kinase (CK) and lactate dehydrogenase (LDH)), and Acute phase protein; C-reactive protein (CRP) were investigated in four presented breeds with MMVD (n=12) (GSD, Pekinjese, Cocker spaniel and Griffon) and apparently healthy dogs (n=12) of the corresponding breed. Results were correlated with the echocardiographic findings.

Cardiac Disease Categorization

Categorization of cardiac diseases was done based on the American College of Veterinary Internal Medicine (ACVIM) guidelines. MMVD was classified into four categories i.e., B1, B2, C, and D (Keene et al. 2019). DCM was classified into two categories, Pre-DCM and clinical DCM (Dutton and López-Alvarez 2018). Secondary cardiomyopathies and pericardial diseases were also depicted according to previous literature (Janus et al. 2014; Treggiari et al. 2017; Bode 2019; Lakhdhir et al. 2020).

Statistical Analysis

Demographic and serum biochemical data were expressed as mean±SD. One way ANOVA was used to analyze intra and intergroup variability and results were considered significant at $P \leq 0.05$ (IBM SPSS statistical version 22.0.0.0).

RESULTS

Based on clinical, radiographic, echocardiographic and electrocardiographic examination, the presence of cardiac disease was confirmed on 72 dogs. These dogs were of twenty different breeds where Griffon and German Shepherd Dogs were the most diagnosed with cardiac diseases constituting 28% (n=20) and 19% (n=14) respectively. Breed distribution of different cardiac diseases is demonstrated in Table 1.

MMVD, DCM, secondary cardiomyopathy (DCM-like phenotype), HTn-CM, myocarditis, pericardial effusion, pericardial mass and heart - base tumor were

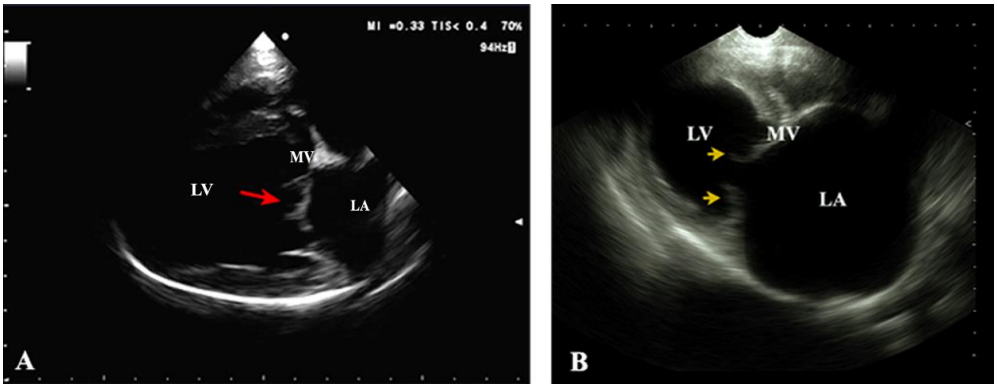

Fig. 1: Right parasternal long axis echocardiographic view- four-chamber view of an eight-year-old male GSD dog showing a thickened mitral valve leaflet (red arrow) (Fig. 1A). Right parasternal tipped long axis- four chamber view of a 10-year-old female Cavalier king Charles showing left atrial enlargement secondary to mitral valve disease. Thickened anterior and posterior leaflet are evident (yellow arrows) (Fig. 1B): LV: left ventricle; MV: mitral valve and LA: left atrium; GSD: German shepherd dog.

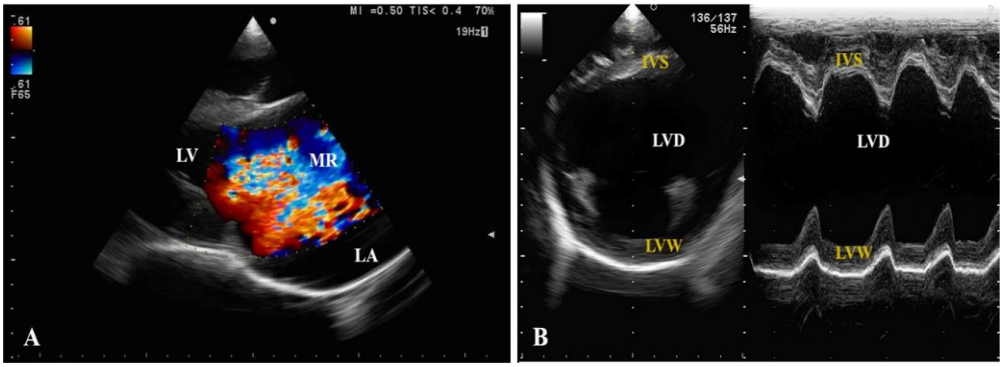

Fig. 2: Right parasternal long axis- four chambers echocardiographic view of a three-year- old female German Shepherd Dog at end-systole diagnosed with DCM showing marked mitral regurgitation indicated by turbulent flow on color flow Doppler mode (Fig. 2A). M- mode guided right parasternal short axis view obtained at papillary muscle level (Fig. 2B) of the same dog showing marked left ventricular dilatation with maintained systolic function (FS=33%): LV: left ventricle; LA: left atrium; Ao: Aorta; IVS: interventricular septum and LVW: left ventricular wall.

Table 1: Demographic distribution of different cardiac diseases among dog population diagnosed with cardiac disease

Dog Breed	Number	%	Body weight (kg) (mean±SD)	Age (year) (mean±SD)
Griffon	20	27.8	10.5±1.0	6.6±1.1
German Shepherd Dog	14	19.4	25.8±2.7	4.8±1.0
Cavilier King Charles	9	12.5	9.5 ±0.9	8.5 ±1.1
Golden Retriever	4	5.6	26.6±0.5	5.8 ±1.7
Bull Dog	3	4.2	13.0±4.5	3.1±2.0
French Bull Dog	2	2.8	13.0±0.6	3.3±1.9
Pekingese	3	4.2	4.2±0.3	6.0±2.2
Cocker Spaniel	3	4.2	14.8±8.6	5.8±4.1
Yorkshire	2	2.8	4.0±0.6	7.7±2.0
Rottweiler	2	2.8	31.0±4.0	2.5±1.5
Boxer	1	1.4	18.5±0.5	8.5±0.5
Corgi	1	1.4	15.0±0.0	12.0±0.0
Caucasian	1	1.4	35.0±0.0	8.0±0.0
Chihuahua	1	1.4	8.0±0.0	8.0±0.0
Malinois	1	1.4	28.0±0.0	7.0±0.0
St. Bernard	1	1.4	38.0±0.0	13.0±0.0
Dachshund	1	1.4	15.0±0.0	3.0±0.0
Pomeranian	1	1.4	10.5±0.0	6.0±0.0
Labrador Retriever	1	1.4	18.0±0.0	7.0±0.0
Beagle	1	1.4	12.0±0.0	6.0±0.0
Total	72	100%		

diagnosed in the presented dogs. MMVD and DCM were the most common diagnoses. Tabulation of different cardiac diseases is presented in Table 2. A significant difference was detected between the breed categories in the age and weight (P≤0.05) (Table 1).

Disease Categories

Distribution of the cardiac diseases in the admitted breeds was listed in Table 2. MMVD represented the most common cardiac affection (48.6%, n=35) (Fig. 1A and 1B), while DCM was the second most detected

Table 2: Acquired cardiac diseases in the admitted dog population

Cardiac disease	Category	Dog Breed	Number of Dogs			%
Mitral valve disease	B1	Griffon	8	29	35	48.6
		Cavalier King Charles	6			
		Golden Retriever	2			
		Labrador Retriever	1			
		Chihuahua	1			
		Corgi	1			
		German Shepherd Dog	3			
		French Bull Dog	1			
		Cocker Spaniel	2			
		Pekingese	3			
		Beagle	1			
	B2	Cavalier King Charles	1	1		
	C	Griffon	3	4		
		Cavalier King Charles	1			
	D	Cavalier King Charles	1	1		
Dilated Cardiomyopathy (DCM)	Pre-DCM	German Shepherd Dog	1	1	12	16.7
	Clinical DCM	German Shepherd Dog	6	11		
		St. Bernard	1			
		Cocker Spaniel	1			
		Caucasian	1			
		Rottweiler	2			
Hypertensive cardiomyopathy (HTn-CM)		Griffon	4	7	7	9.7
		Golden retriever	2			
		Pomeranian	1			
DCM-like phenotype		Dachshund	1	6	6	8.3
		GSD	1			
		Griffon	2			
		Yorkshire terrier	1			
		Bulldog	1			
Pericardial Effusion		French Bull Dog	1	6	6	8.3
		Bull Dog	2			
		Griffon	2			
		German Shepherd Dog	1			
Myocarditis		Malinois	1	2	2	2.8
		Yorkshire terrier	1			
Microcardia		German Shepherd Dog	1	2	2	2.8
		Griffon	1			
Pericardial mass		German Shepherd Dog	1	1	1	1.4
Heart-base tumor		Boxer	1	1	1	1.4
	Total			72		100 %

affection at a prevalence rate of 16.7 % (n=12) after MMVD (Fig. 2A and 2B). MMVD B1 was the most detectable stage; 82.85% (29/35) among the MMVD categories.

At a lesser extent, secondary cardiomyopathies causing DCM like phenotype were detected in 8.3% of the dogs, while myocarditis was presumptively diagnosed in 2.7% of the cases. HCM like phenotype or HTn-CM was also encountered in 9.7% of the dogs. PE was noticed in 8.3% of the dogs. Pericardial masses and heart base tumor were also detected as individual cases.

Clinical Characteristics of Cardiac Disease

Heart murmurs (n= 52), exercise intolerance (n=27) and cough (n=25) were the most common presenting signs for all disease categories. Dyspnoea was detected in 12 dogs, while pallor was found in 11 dogs. Syncope (n=8), ascites (n=8) and cyanosis (n=5) were less encountered in the presented cases.

Systemic hypertension was detected in seven dogs (blood pressure: 173.80±10.98mmHg). Five of these seven dogs were bearing clinical signs relevant to renal disorders, while the remaining two were showing clinical signs of hyperthyroidism.

Echocardiographic Examination of Cardiac Disease

Echocardiographic examination allowed the diagnosis and categorization of MMVD. Thickening of the mitral valve leaflets without any cardiac remodeling were suggesting the presence of MMVD- B1. In dogs with MMVD-B2 where no clinical signs were noticed, further cardiac remodeling was detected secondary to MR as detected through color flow Doppler scanning. Left atrial dilatation (LAD) was evident, where LA/Ao ratio exceeded 1.6. Dogs diagnosed with MMVD-C demonstrated the same changes along with signs of congestive heart failure (CHF) on radiographic examination. Refractory cases of MMVD, showed marked LAD and left ventricular dilatation (LVD).

The presence of marked LVD and LAD with decreased systolic function (FS< 21% and EF <46%) with/out right chamber dilatation was suggestive of DCM. Mild LAD and LVD with impaired systolic function in cases having parallel systemic illnesses was indicative of secondary cardiomyopathies (DCM-like phenotype). Two dogs had no chamber remodeling, however they had poor myocardial contractility suggested the presence of myocarditis. Hypertrophy of the left ventricular wall and inter-ventricular septum without evidence of left ventricular outflow obstruction on color-Doppler scanning

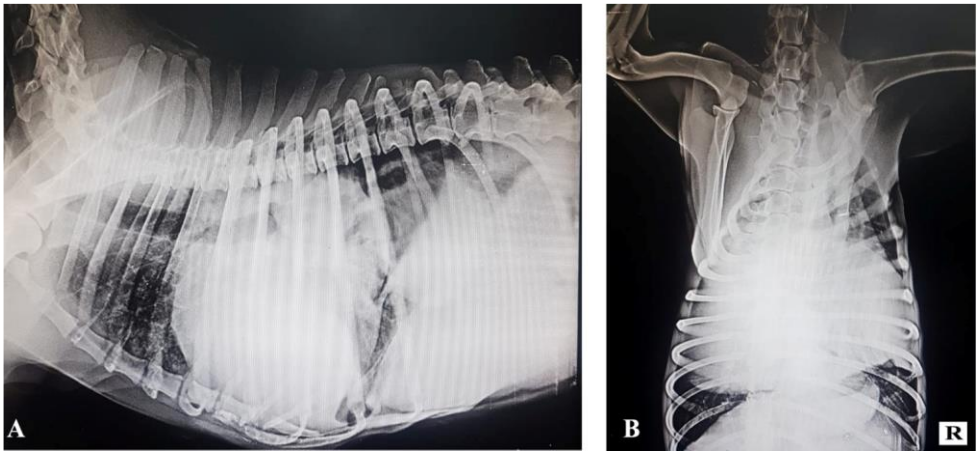

Fig. 3: Right lateral (Fig. 3A) and ventrodorsal (Fig. 3B) thoracic radiographs of a three-year- old female German Shepherd dog diagnosed with dilated cardiomyopathy showing marked cardiomegaly. The cardiac silhouette is occupying five intercostal spaces on the lateral view.

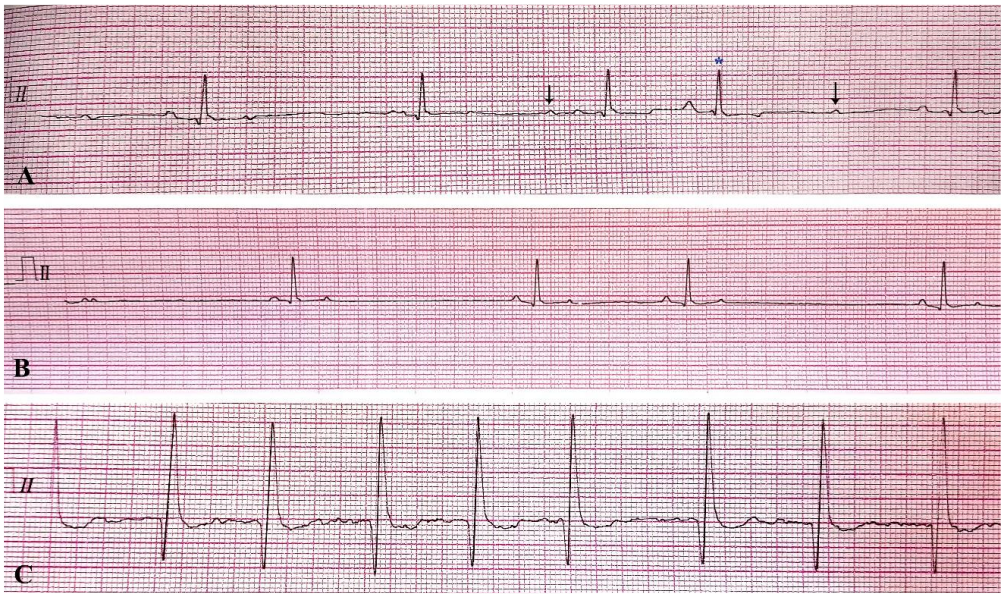

Fig. 4: Lead II ECG of a 4-year- old female Dachshund diagnosed with hypothyroidism- induced cardiomyopathy. Note the presence of second degree AVB (black arrows) with a single APC (blue asterisk) (Fig. 4A)*. Lead II ECG of a 7-year-old male Malinois dog diagnosed with myocarditis, a sinus bradycardia is demonstrated with average heart rate 50 bpm (Fig. 4B)*. Lead II ECG of a 3-year-old female German Shepherd Dog diagnosed with clinical dilated cardiomyopathy associated with congestive heart failure showing atrial fibrillation and evidence of chamber enlargement (Tall R wave>2.5 mV, deep s waves >0.8 mV and wide QRS complexes> 0.04 s) (Fig. 4C)**: *Paper settings; 10 mm/mV and 50 mm/s: **Paper settings; 5 mm/mV and 50 mm/s.

was noticed in cases having HTn-CM, where five out of seven dogs had LAD secondary to MR. Anechoic fluid build-up in the pericardial sac was detected in dogs with PE with no identifiable masses or signs of right-sided enlargement. In one dog, PE was found in conjugation with multiple discrete hypoechoic pericardial masses which was more suggestive of pericardial mesothelioma. The presence of a hypoechoic heterogenous mass at the left atrioventricular junction was detected in one dog and indicated the presence of heart base tumor (HBT), which more likely to be HSA.

Radiographic Evaluation of Cardiac Disease

The main radiographic findings associated with cardiac disease were local chamber enlargement represented mainly by LAD in six dogs with MMVD and five dogs with HTn-CM, and left ventricular enlargement (LVE) in six dogs with DCM-like phenotype. Generalized cardiomegaly was spotted in 12 dogs with clinical DCM (Fig. 3A and 3B), while a globoid like cardiac silhouette was detected in seven dogs with pericardial disorders. Signs of CHF were recorded in 30 dogs, where 22 dogs showed pulmonary edema and congestion and eight dogs with DCM showed moderate pleural effusions. In one dog with HBT, a radiopaque ovoid structure was overlapping the dorso-caudal aspect of the cardiac silhouette on lateral thoracic radiograph. Reduced cardiac silhouette (<2 intercostal spaces) along with collapsed caudal vena cava was detected in two dogs in a state of shock.

Electrocardiographic Examination of Cardiac Disease

ECG findings (Fig. 4A, 4B and 4C) related to chamber enlargement were detected in 11 dogs with DCM and five dogs with MMVD including tall R waves (>2.5mV in lead II), deep S waves (>0.8 mV in lead I), p pulmonale (>0.4mV) and p mitrale (>0.04 mS). Conduction disturbances and arrhythmias were also encountered including wide QRS complexes (>0.04 mS and 0.07 mS in small and large breeds respectively) in 11 dogs with DCM, intermittent VPCs in two dogs with DCM, atrial premature

Table 3: Serum cardiac biomarkers of MMVD investigated dogs

Breeds	Biomarkers		
	cTnl	CK	LDH
	(ng/mL)	(IU/L)	(IU/L)
GSD			
Control	0.18±0.05[b]	88.00 ± 2.64[b]	310.0±50.11[b]
MMVD	0.42±0.10[a]	206.0±4.70[a]	590.33±8.50[a]
Pekinjese dogs			
Control	0.12±0.04	87.00±5.00[b]	240.00±3.51[b]
MMVD	0.23±0.12	233.00±20.0[a]	290.00±4.00[a]
Cocker spaniels			
Control	0.11±0.04	79.67±2.5[b]	253.00±18.68[b]
MMVD	0.19±0.18	204.7±17.4[a]	344.67±22.00[a]
Griffon dogs			
Control	0.09±0.02[b]	82.67±6.50[b]	225.67±22.28[b]
MMVD	0.25±0.09[a]	192.7±6.49[a]	291.0±31.00[a]

Values represent mean±SD: Means with different superscripts (a, b) within the same columns are significantly different at P<0.05. cTnI: cardiac troponin I; CK: creatine kinase; LDH: lactate dehydrogenase.

complexes (APCS) in one dog with hypothyroidism-induced cardiomyopathy. 1st degree atrioventricular block (AVB) was recorded in one dog with MMVD- B1, while 2nd AVB was discovered in two dogs diagnosed with secondary cardiomyopathy. Atrial fibrillation (AF) was noticed in two dogs diagnosed with DCM and MMVD-C). Sinus bradycardia was confirmed in three dogs; two of them were diagnosed with secondary cardiomyopathy (DCM-like phenotype) and myocarditis respectively and the remaining dog had MMVD-B1.

Serum Biochemical Evaluation of Cardiac Disease

Serum biochemical analysis was performed on 15 dogs. Eight dogs out of them were suspected to have thyroid gland diseases based on clinical examination (weight gain/loss, aggressive behaviour/lethargy, systemic hypertension, alopecia, polydipsia and polyuria) along with myocardial structural and functional abnormalities as diagnosed by echocardiography, these dogs were tested for thyroid profile including both serum basal thyroxine (T4) and thyroid stimulating hormone (TSH). Six dogs out of the eight dogs had reduced serum T4 and elevated TSH concentrations than the reference ranges (9.59±1.26nmol/L and 1.06±0.20ng/mL respectively), while the other two dogs showed elevated T4 concentration (75.36 and 90.63nmol/L).

Five dogs had clinical signs suggestive of renal disorders (polydipsia, polyuria, weight loss, halitosis, hyporexia, systemic hypertension and lethargy) with detected LVH based on echocardiographic examination, were tested for serum BUN and creatinine to confirm the diagnosis. These dogs had marked azotaemia, where the serum creatinine and BUN concentrations were 5.96±2.76 and 141.4±100.9mg/dL, respectively. Serum phosphorus and potassium levels were within reference ranges (4.0±1.2mg/dL and 3.70±0.95mEq/L, respectively).

In two dogs suspected to have myocarditis, where echocardiographic examination revealed myocardial dysfunction in the absence of structural abnormalities, were evaluated for complete blood picture and differential leukocytic count along with serum troponin levels. Elevated serum troponin concentration (2.3 and 5.6ng/mL), leukocytosis (18.69 and 19.80×103cell/µL) and neutrophilia (15.50 and 16.62×103cell/µL) as well as thrombocytopenia (134 and 150×103cell/µL) were detected. Results of the cardiac biomarkers are summarized in Table 3.

DISCUSSION

This study is the first to report the distribution of acquired canine cardiac diseases in Egypt. Twenty different breeds of various age and sex categories were assigned to the study which reflected the breed variation in Egypt. Among the twenty presented breeds, GSD and Griffon dogs were the most affected populations. The distribution of the cardiac affections showed minor differences from previous worldwide reports. Both MMVD and DCM represented the majority of the acquired affections in the presented breeds.

The male population was over presented (61.11% of the total cases) than the female population which agreed with previous studies confirming the male predisposition to the majority of cardiac diseases (Dutton and López-Alvarez 2018; Hoque et al. 2019; Keene et al. 2019). GSD and Griffon dogs were the most affected breeds in the present study with no identifiable cause. We propose that genetic causes might have contributed to breed predisposition to cardiac diseases.

MMVD was the most detectable cardiac disease (48.6%, 35/72), primarily in small breed of dogs (27/35), which coincided with the previous reports (Fox 2012; Keene et al. 2019). Stage B1 followed by stage C represented the majority of the MMVD cases (82.85 and 11.4%, respectively). These results were comparable to a previous MMVD study in miniature poodle, where stage B1 represented the majority of the cases (66.6%), however, stage B2 was the second detected MMVD category (37.5%) in the same study (Meurs et al. 2019). Unlikely, another study showed the predominance of stage B2 and C (29 and 51.3%, respectively) (Chan et al. 2019).

DCM was the second most observed affection in the presented dogs by constituting 16.67% of the cases (12/72), which exceeded the previously reported range (8%) (Vollmar et al. 2019). The affected population consisted of medium to giant breed dogs as well as Cocker spaniels which agreed with the previous studies (MacPete 2018; Dutton and López-Alvarez 2018; Vollmar et al. 2019).

Secondary cardiomyopathies presented with DCM-like phenotypes were detected in a smaller population (6/72) concomitant with hypothyroidism which was correlated by the presence of reduced T4 concentration with elevated serum TSH concentration (Ferguson 2007). These dogs also suffered from sinus bradycardia and APCs based on ECG examination which were in accordance with previous reports (Smith et al. 2015).

In the present study, seven cases (9.72%) showed HCM like phenotype secondary to systemic hypertension. This systemic hypertension was correlated to chronic renal diseases in five cases by the presence of marked azotemia (Kumar et al. 2010; Smith et al. 2015; Hall et al. 2016; Dahlem et al. 2017; Elsharkawy and Torad 2021). On the other hand, two cases were correlated to hyperthyroidism which was confirmed by elevated serum basal T4 level (Kumar et al. 2010; Köhler et al. 2012; Smith et al. 2015).

Interestingly, pericardial disorders (PE and pericardial mass) constituted 8.3% of the total affections which in accordance to previous reports with the predominance of PE (Tobias 2010; Bode 2019). HBT was uncommon

finding which was evident in one dog by echocardiographic examination at the atrioventricular junction and is thought to be a HSA regarding the site of incidence (Treggiari et al. 2017).

Two dogs (2.77%) that were presumptively diagnosed as myocarditis based on altered serum biochemical analsysis as well as evident myocardial dysfunction and bradyarrhythmia on echocardiography and ECG respectively. Eventual diagnosis of myocarditis couldn't be confirmed by postmortem examination as recommended by similar surveys (Janus et al. 2014; Lakhdhir et al. 2020) as the dogs were alive by the end of the study.

Microcardia was an incidental finding in two cases which was detected as a subsidiary consequence to fluid loss by longstanding diarrhea and chronic vomiting (Chetboul 2020).

In the present investigation, significant increase in the cTnI values was recorded in GSD and Griffon dogs with MMVD only, while serum CK and LDH levels was elevated in all investigated breeds. Insignificant increase of serum cTnI in some of the presented breeds could be explained by chronic cardiac remodeling process with increased MMVD severity (Chan et al. 2019). However, elevated CK and LDH levels may not only present with cardiac damage but also with several localized and systemic diseases (Aktas et al. 1993; Bakirel and Gunes 2009; Kopanke et al. 2018). Interestingly, the CRP was undetectable in MMVD dogs compared to healthy one as previously reported (Ljungvall et al. 2010). Unlikely, increased CRP values have been recorded in dogs with different cardiac affections (Rush et al. 2006; Cunningham et al. 2012) as well as dogs with CHF due to MMVD (Reimann et al. 2016).

Our study was conducted on a narrow population of dogs with acquired cardiac affections. In addition, absence of the owners' compliance for required clinical investigations has limited the diagnostic options. Further studies should include a wider population of the canine species for more accurate depiction of the prevalence rates and to investigate the weight, breed and gender predisposition to cardiac affections.

Conclusion

The current survey provided preliminary information about the distribution of acquired cardiac affections in Egypt. Distribution of the acquired cardiac affections showed minor differences from previous geographical surveys in UK and USA. MMVD and DCM constituted a considerable population of the acquired affections. Finally, considering the breed predisposition for some of the affections in the current study, efficient national screening programs should be established for such breeds.

Authors' Contribution

Samar Hassan Elsharkawy Clinical investigator and wrote the initial paper draft. Faisal Abdel-Samad Torad1 Clinical investigator and reviewed the paper draft. Nashwa Adel Abu-Aita2 conducted and interpreted the laboratory investigations. Ahmed Kamel Abdel-Ghany3 specialized interventional human cardiologist who guided and reviewed the medical procedures. Inas Nabil Elhussieny1 principal investigator and designed the study protocol.

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