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Original article

DIAGNOSTIC AND MORPHOMETRIC STUDIES ON DILATED CARDIOMYOPATHY IN MIXED BREED CATS

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Summary

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Feline dilated cardiomyopathy (DCM) is a rare condition, with idiopathic etiology, non-specific clinical manifestations, and sudden death. The DCM diagnostic protocol was studied in mixed-breed cats along with the morphometric study of their hearts. Sixteen mixed-breed cats were examined for diagnostic studies and six mixed-breed cats have been studied anatomically. DCM cats had severe respiratory distress and abdominal distention. The physical examinations revealed an increase in respiration rate of 89±5.90 min^{-1} and pulse rate of 166±5.25 min^{-1}. The diagnosis protocol revealed abnormal darker dots in IDEXX SNAP Feline pro-BNP test. Macro-anatomically, the DCM heart was large, ovoid in shape with a rounded apex, the interventricular septum thickness was significantly decreased to 2.9±0.03 mm, and the left ventricular lumen of DCM was significantly increased to 27.2±0.39 mm. Morphometrically, the whole size of the DCM heart was 43.1±0.03 mm. Radiographic examinations showed marked pleural effusion and abnormal enlargement of the heart. In echocardiography DCM cats showed a significant increase in heart rate, left ventricle internal diameter in diastole (LVIDd), interventricular septum systole (IVSs), left ventricle internal diameter in systole (LVIDs), and left atrium to aortic diameter ratio (LA/AO). The colour Doppler echocardiography showed turbulence in mitral, tricuspid, and aortic valve regurgitation. Pulsed and continuous wave Doppler echocardiography revealed a disparity in the flow velocity associated with valve regurgitation. Respiratory distress in cats should be investigated for the presence of cardiac diseases.

Key words: coronary artery, dilated cardiomyopathy, Doppler, echocardiography, heart, macro-anatomy

INTRODUCTION

Cardiomyopathies are very common conditions facing small animal clinicians worldwide. They include a heterogeneous group of myocardial disorders of unknown etiology. Data about prevalence demonstrated that up to 20% of feline populations are affected by cardiac diseases (Paige *et al.*, 2009), one of these conditions being feline dilated cardiomyopathy (DCM). It can be defined as a disease of ventricular muscles manifested by systolic myocardial failure (Uppe *et* *al.*, 2013). This inherent disease could lead to myocyte weakness and a decrease in whole myocardial contractility and eventually an increase in the left ventricle (LV) internal diameter, reduction of fractional shortening, and ejection fraction (Kittleson & Côté, 2021a).

Feline DCM is considered a rare condition, but it is still recorded in about 5% of cardiomyopathic cases especially in mixed breed cats (Hambrook and Bennett, 2012). Some cats show good compensation for the condition while in others it may result in arterial thromboembolism, heart failure, and sudden death (Fuentes *et al.*, 2020). Although the etiology was idiopathic, some records pointed at taurine amino acid deficiency especially in cats fed on a single-ingredient diet (Thatcher, 2010). It characterised by non-specific clinical manifestations, but it was found that tachypnea, dyspnea and hypothermia are the most predominant clinical presentations (Hambrook & Bennett, 2012). Pulmonary oedema, pleural effusion, and ascites are also recorded in other cases (Wright *et al.*, 1999).

Diagnostic protocol was based on careful clinical examination, chest radiography, echocardiography, and laboratory investigation. Although radiography is considered as the gold standard for confirmation of pulmonary oedema (Guglielmini & Diana, 2015), it was found insensitive for identification of mild or moderate conditions associated with cardiomyopathy. In some cases, heart might appear radiographically normal although the case severity level is extreme (Schober *et al.*, 2014). In the same manner, sensitivity of electrocardiogram for detection of DCM is low as there is a little chance for arrhythmia to be associated with cardiomyopathies in cats (Romito *et al.*, 2018).

Echocardiography is a decisive diagnostic tool for feline DCM. The most recorded findings included increase in heart rate, left ventricle internal diameter in both systole (LVIDs) and diastole (LVIDd), decrease in fractional shortening. Regarding colour flow Doppler echocardiography, findings included both mitral and tricuspid valves systolic regurgitation (Kittleson & Côté, 2021b). Laboratory biomarkers as troponin and natriuretic peptides are useful for detection of degree of myocardial damage and monitoring of the disease course (Gavazza *et al.*, 2021).

The relevant literature on macro-anatomy of the healthy cat heart and DCM hearts is scarce. The present study described and viewed the macro-anatomical details on the healthy cat heart in comparison to the dilated cardiomyopathy heart in addition to the comparison between the morphometric records of healthy and DCM hearts. The coronary vessels were viewed in both healthy and DCM hearts with their distributions over the cardiac chambers.

MATERIALS AND METHODS

Ethical approval

The use of animals for the current study was ethically approved by Cairo University's Institutional Animal Care and Use Committee (CU-IACUC) with number VET CU 01122022608. All methods were performed in accordance with the relevant guidelines and regulations. Informed consent to use the animals in this anatomical study was obtained from the owners.

In the present study, 22 adult mixed breed cats of both sexes from the hospital of the Faculty of Veterinary Medicine and pet clinics were examined. Sixteen mixed-breed cats were included in diagnostic studies and six mixed-breed cats have been studied anatomically.

Diagnostic studies

Sixteen mixed breed cats were subjected to thorough clinical examination. The number included nine apparently healthy adult cats (6 males and 3 females) and seven adult cats (5 males and 2 females) suffering from DCM. All admitted cases were recorded for vaccination, dietary and management history besides full data about the present clinical manifestations noticed by the owner. Complete visual examination was carried out and rectal temperature, respiratory and pulse rates were recorded. Physical examination was applied to all admitted cats. Body systems examination was performed, especially chest percussion and auscultation (Englar, 2017). IDEXX SNAP Feline pro-BNP test was performed for detection of stretch and stress of myocardium (Hezzell *et al.*, 2016). Chest radiography was performed using VIVIXS-V-series (Medlink Imaging, Vieworks company, China) according to the method described by (Thrall *et al.*, 2022). The examined animals were positioned on the right side without sedation and left lateral radiographic views were obtained for detection of heart size and assessment if there was pleural effusion, pulmonary oedema, or abdominal effusion.

Echocardiography was performed using ultrasound machine (EDAN DUS-60, China) with a micro-convex sector transducer of 7.5 MHz (Ware, 2007). Cats were positioned in right lateral recumbency and restrained without sedation. A complete 2-Dimensional (2-D) and Motion-mode (M-Mode) exam was applied with standard views including right parasternal long and short axis (Sahn *et al.*, 1978) (Thomas *et al.*, 1993). For Doppler echocardiography, left apical parasternal standard imaging views were taken for colour, pulsed wave, and continuous wave Doppler examination (Rohrbaugh *et al.*, 2020).

Anatomical studies

Macro-anatomy of the heart was studied in six cats: four mixed breed cats (2 healthy admitted dead to the Faculty of Veterinary Medicine hospital and pet clinics and 2 suffering from DCM that suddenly died after severe respiratory distress). Manual dissections were applied for opening the thoracic cage to view the position of the heart and its external features. Sagittal sections were applied to two of them. Morphometric records of the healthy cat heart and DCM hearts of the previously dissected cats were presented as mean ± standard error. For evaluation of coronary vascular architecture, two recently dead cats (1 heathy cat and 1 with DCM) were cannulated at the thoracic aorta, rinsed with warm saline solution, and injected with latex neoprene coloured with red Rotring ink (El-Bably & Abouelela, 2021), fixed with diluted glacial acetic acid for 30 min then flushed with water and dissected**.** The coronary arteries and their branches were viewed clearly. The specimens were photographed. The Nomina Anatomica Veterinaria (NAV, 2017) nomenclature was adopted.

Statistical analysis

All obtained data were imported to a Microsoft Excel 2021 spreadsheet. Statistical range was shown as mean ± standard error. Student's t-test was applied to compare apparently healthy and diseased groups using SPSS program version 20. P value ≤0.05 was considered significant (Levesque, 2007). Data from individual cases concerned with Doppler echocardiography were illustrated individually and not subjected to statistical analysis.

RESULTS

Diagnostic study of DCM in cats included physical examination of the suspected cases. The clinical manifestations showed mostly inappetence, dyspnea, tachypnea, generalised weakness, and abdominal distention. Sudden death was recorded after severe respiratory distress in two cases. Physical examination statistical data showed significant (P≤0.001) increase in both respiration and pulse rates (89±5.90 min^{-1}) and (166±5.25 min^{-1}) respectively in cats affected with DCM compared to apparently healthy cats (41±1.89 min^{-1} and 124±5.67 min^{-1}) respectively. Significant (P≤0.01) decrease in the rectal temperature was recorded in diseased (38±0.08 °C) compared to healthy cats (38.3±0.06 °C). Chest auscultation revealed murmurs and muffled lung sound in some cases. Chest percussion showed dull sound over the lung field area with increase at the area of the cardiac dullness (Table 1).

IDEXX SNAP Feline pro-BNP test demonstrated abnormal darker dots in the sample spot in all diseased conditions (Fig.1A). Comparison of the colour intensity of the test's sample spot to potential key test results showed high concentration of NT-proBNP that exceeded 200 pmol/L.

The radiographic examinations of DCM cases showed marked degree of pleural effusion that compressed main bronchi and lungs in the left lateral radiographic view. Abnormal enlargement of the heart was recorded with visual difficulty due to massive degree of accumu-

Table 1. Physical parameters in apparently healthy and diseased cats suffering from DCM

Physical parameters	Control group	DCM group
Respiration rate (min^{-1})	41±1.89	89±5.90***
Pulse rate (min^{-1})	124±5.67	166±5.25***
Rectal temperature (°C)	38.3±0.06	38±0.08**

***P≤0.001; **P≤0.01; *P≤0.05.

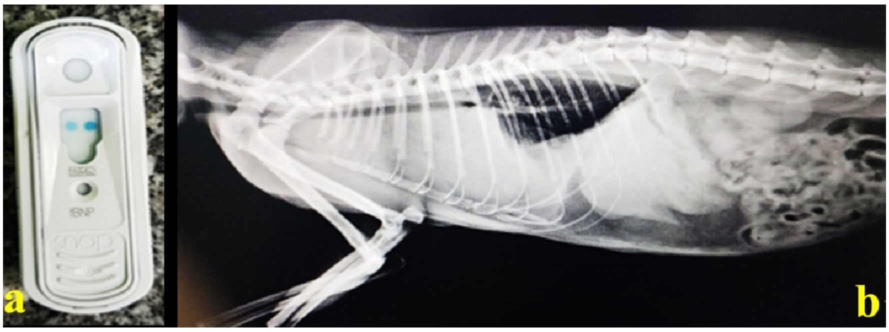

Fig. 1. A. IDEXX SNAP Feline pro-BNP test showed the presence of darker dot in the sample spot (right) indicating high concentration of p-BNP >200 pmol/l; **B.** Left lateral radiographic view in two years, mixed breed tom cat affected with DCM admitted with severe dyspnea. The chest was filled with a large volume of fluid (pleural effusion) and presence of abdominal effusion.

Table 2. Echocardiographic parameters in apparently healthy and diseased cats suffering from DCM.

Echocardiographic parameters	Control group	DCM group
Heart rate (bpm)	190±1.48	213±4.4***
Interventricular septum diastole (mm)	3.9±0.03	3.1±0.08***
Left ventricle internal diameter diastole (mm)	12.6±0.12	21.2±0.55***
Left ventricle posterior wall diastole (mm)	4.3±0.07	2.91±0.05***
Interventricular septum systole (mm)	5.5±0.06	6±0.07***
Left ventricle internal diameter systole (mm)	7±0.16	13.1±0.44***
Left ventricle posterior wall systole (mm)	6.2±0.13	6±0.10
Left atrium/aortic ratio	1.29±0.01	3.23±0.07***
Fractional shortening (%)	44.3±1.51	38.1±1.31**

***P≤0.001; **P≤0.01; *P≤0.05.

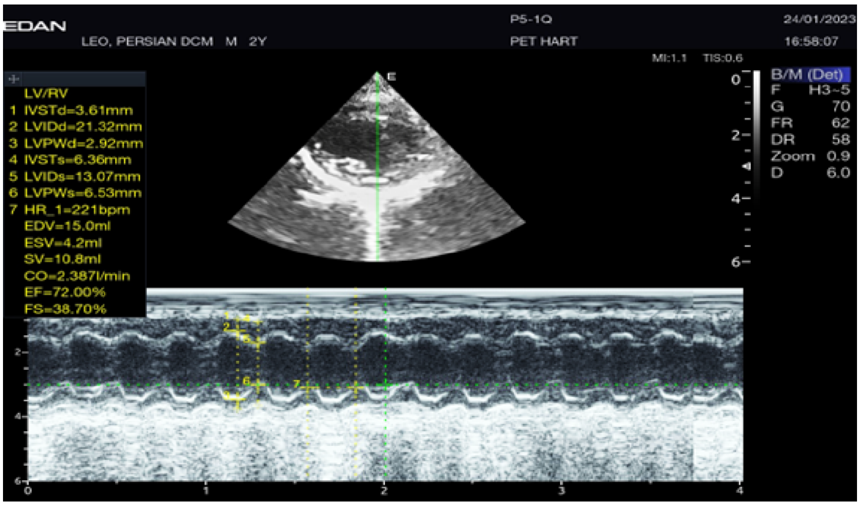

Fig. 2. M-mode echocardiographic view in two years, mixed breed tom cat with DCM. All the measurements included IVSs, IVSd, LVIDs, LVIDd, LVPWs, LVPWd, ejection fraction (EF%) and fractional shortening (FS%).

lated fluids. In some cases the presence of ascites was associated with pressure on the internal abdominal organs (Fig.1B).

In diseased cats, the echocardiography of the right parasternal short axis in M-mode view showed significantly (P≤0.001) increased heart rate, left ventricle inner diameter in diastole (LVIDd), left ventricle inner diameter in systole (LVIDs), interventricular septum thickness during systole (IVSs), and left atrium to aortic diameter (LA/AO) ratio compared to apparently healthy cats (Table 2). Significant (P≤0.001) decrease was recorded in DCM cats including interventricular septum diastole (IVSd) and left ventricle posterior wall diastole (LVPWd) while this significant decrease was moderate ($P \leq 0.01$) for fractional shortening (Table 2). There was marked dilatation of the left ventricle with decrease in both ejection fraction and fractional shortening (Fig. 2).

The pulsed wave Doppler echocardiography in DCM cats showed clear mitral regurgitation presented by aliasing (Fig. 3A). Continuous wave Doppler showed mitral regurgitation maximum velocity of 326.97 cm/s in one case and 249.94 cm/s in another case; mitral valve flow E-wave velocity was recorded as 137.67 cm/s in one case (Fig. 3B) while in the other case it was 196.27 cm/s. Tricuspid valve regurgitation was also detected in two cases that appeared as turbulence in colour, and continuous wave Doppler showed tricuspid regurgitation with maximum velocity of 201.3 cm/s. Aortic regurgitation appeared as turbulence in colour Doppler (Fig. 4). Pulsed wave Doppler showed velocity of 85.95 cm/s (Fig. 4A) while continuous wave Doppler showed maximum flow velocity of 225 cm/s and regurgitation flow velocity of 283.95 cm/s (Fig. 4B).

The normal cat heart position was situated at the left and right sides extending from 5th to 7th rib (Fig. 5A,D), while the

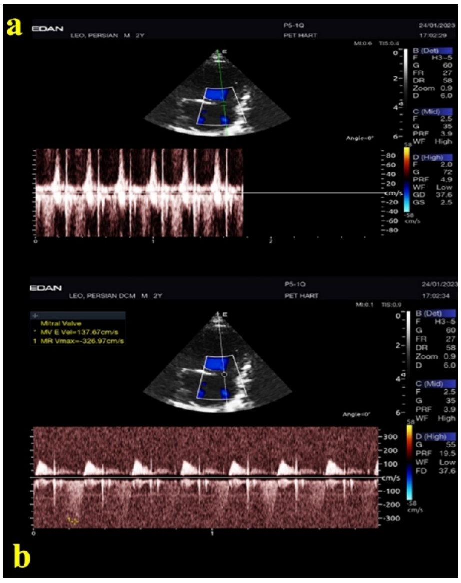

Fig. 3. A. Pulsed wave Doppler echocardiography (left apical view) in two years, mixed breed tom cat with DCM, showed mitral regurgitation with aliasing; **B.** Continuous wave Doppler showed mitral regurgitation: E-wave was estimated and showed velocity of flow exceeding 100 cm/s (MV E-wave =137.67 cm/s), mitral regurgitation velocity (MR Vmax=326.97 cm/s).

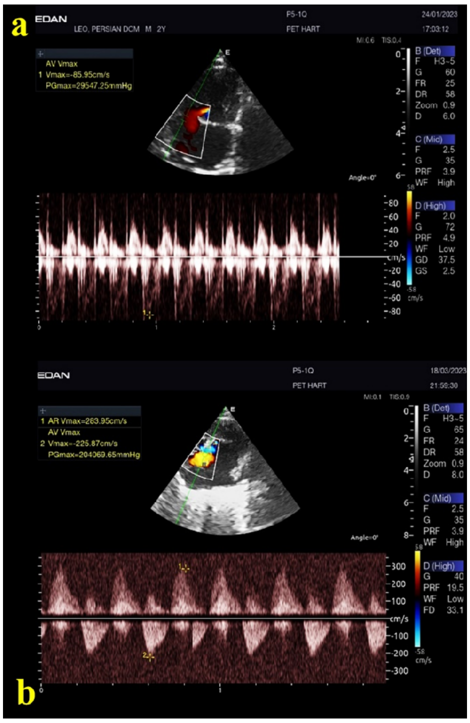

Fig. 4. A. The colour Doppler (left apical view) of a mixed breed tom cat with DCM showed aortic regurgitation appeared as turbulence colour - pulsed wave doppler on aortic valve (AV) with velocity of 85.95 cm/s; **B.** Continuous wave Doppler showed maximum flow velocity of 225 cm/s and regurgitation velocity of 283.95 cm/s.

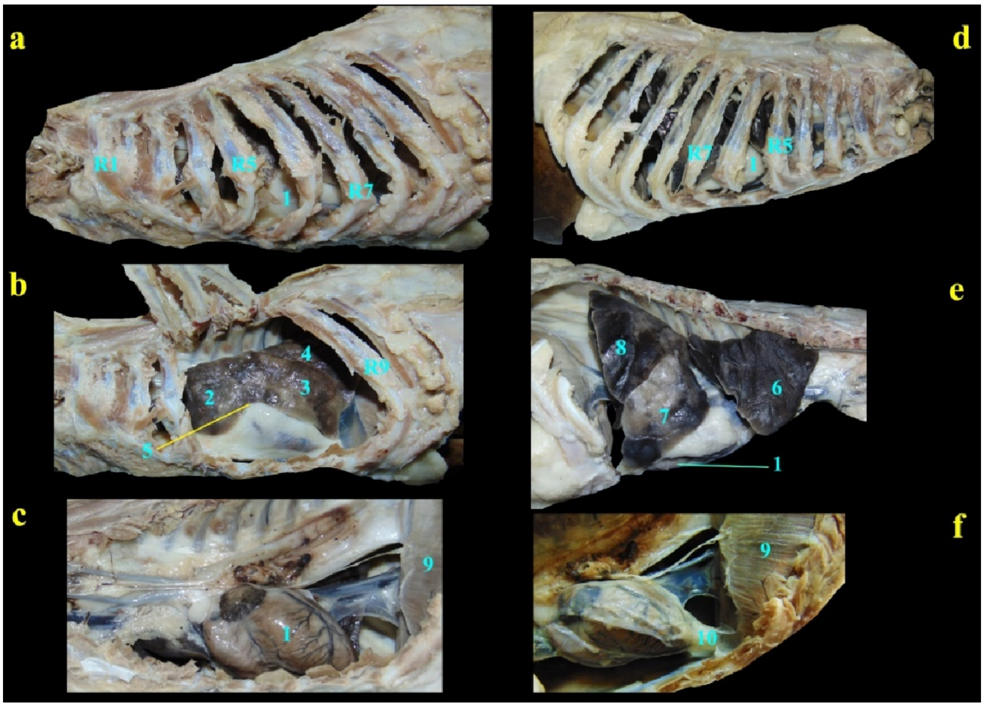

Fig. 5. A, D: Photographs showing the left and right views of thoracic cage of a mixed breed cat; **B, C:** The ribs were reflected viewing the left lung and heart position; **E, F:** the right lung and the heart *in situ;* R1. First rib; R5. Fifth rib; R7. Seventh rib; R9. Ninth rib; 1. Heart; 2. Cranial apical lobe of left lung; 3. Caudal apical lobe of left lung; 4. Caudal lobe of the left lung; 5. Cardiac notch (deep); 6. Right apical lobe of the right lung; 7. Middle lobe of right lung; 8. Caudal lobe of right lung; 9. Diaphragm; 10. Phrenicopericardiac ligament.

left cardiac notch of the lung (area of auscultation) (Fig. 5B) was located at the 5th and 6th intercostal space, moreover, the right area of auscultation (Fig. 5D,E) was smaller locating at the 5th intercostal space. The heart was fixed to the sternum and diaphragm by a phrenicopericardiac ligament (Fig. 5F). The number of observed ribs in cat was 13. The shape of the normal cat heart was ovoid with a pointed apex (Fig 5C and 6A) while the DCM heart had a large ovoid shape with rounded apex (Fig. 6B).

Four heart chambers formed the cat heart as the right and left atria and ventricles (Fig 7A). The mitral valve opened between the left atrium and ventricle, and the tricuspid valve opened between the right atrium and ventricle (Fig. 7A,B). The right and left auricles were ear-like with serrated ventral borders (Fig. 9B, C, D), carrying internally pectinate muscles (Fig. 7A).

The great vessels of the cat heart were the ascending aorta arising from the left ventricle, related caudally to the pulmonary trunk covered by pulmonary fat and medial to the left auricle (Fig. 8 & 9). The ascending aorta gave brachiocephalic trunk and left subclavian artery then continued as descending aorta (Fig 8C & 9A). On the right side of the heart appeared the cranial vena cava, the right vena azygos

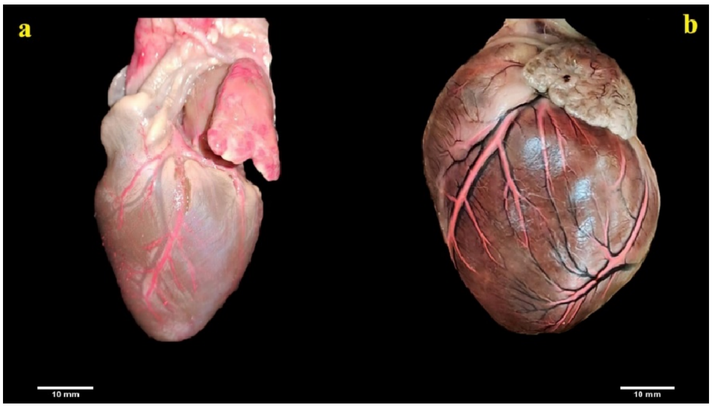

Fig. 6. Photographs showing the difference in sizes between the normal heart (**A**) and dilated heart (**B**) of mixed breed cat.

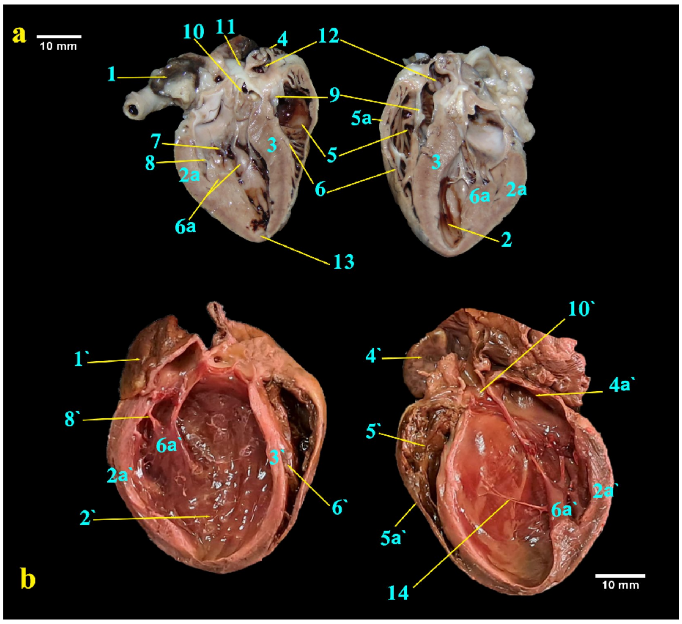

Fig. 7. A. The sagittal sections of the normal heart; **B.** The sagittal sections of heart of a mixed breed cat affected with DCM. 1. Left atrium; 2,2`. Left ventricle; 2a,2a`. Wall of the left ventricle; 3,3`. Interventricular septum; 4,4`. Right auricle; 5,5`. Right ventricle; 5a,5a`. Wall of right ventricle; 6,6`. Papillary muscle of right ventricle; 6a,6a`. Papillary muscles of left ventricle; 7. Chorda tendineae of mitral valve; 8,8`. Cusp of mitral valve; 9. Cusp of tricuspid valve; 10. Aortic valve; 11. Aortic arch; 12. Pectinate muscle; 13. Apex of heart; 14. Trabecula septomarginalis.

and the caudal vena cava where they drained in the right atrium (Fig 8B & 9B). The pulmonary veins drained in the left atrium, ventral to the descending aorta on the left side, also appearing on the right side dorsal to the caudal vena cavae.

Coronary vascular architecture of cat showed that the ascending aorta was branched into the left coronary artery and right coronary artery (Fig. 10 & 11). The left coronary artery gave three branches; septal branch and interventricular paraconal artery, then continued as left circumflex branch which shortly branched into diagonal interventricular branch, on the left side of the heart near to the caudal border of heart (Fig. 10A,B & 11A). The left circumflex branch continued caudally

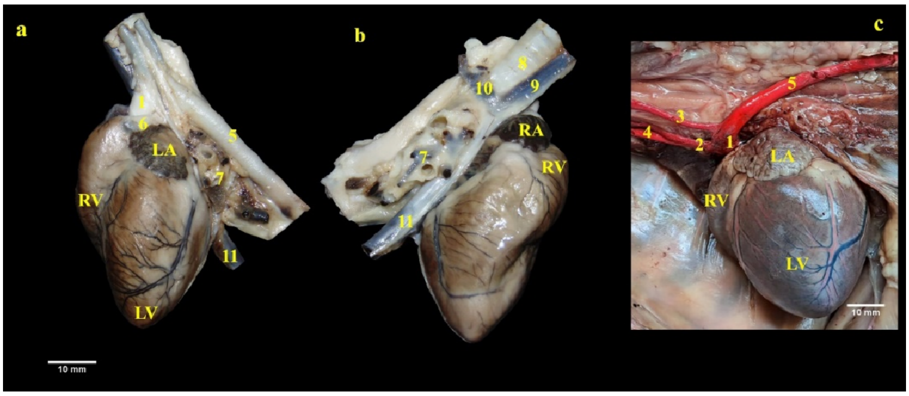

Fig. 8. A. The left side of heart of a mixed breed cat; **B** right side of the heart; **C:** left side of a DCM heart injected with red latex neoprene, showing the great heart vessels. LA. Left auricle; LV. Left ventricle; RA. Right auricle; RV. Right ventricle; 1. Ascending aorta; 2. Brachiocephalic trunk; 3. Left subclavian artery; 4. Right and left common carotid arteries; 5. Descending aorta; 6. Pulmonary trunk; 7. Pulmonary veins; 8. Trachea; 9. Cranial vena cava; 10. Right vena azygos; 11. Caudal vena cava.

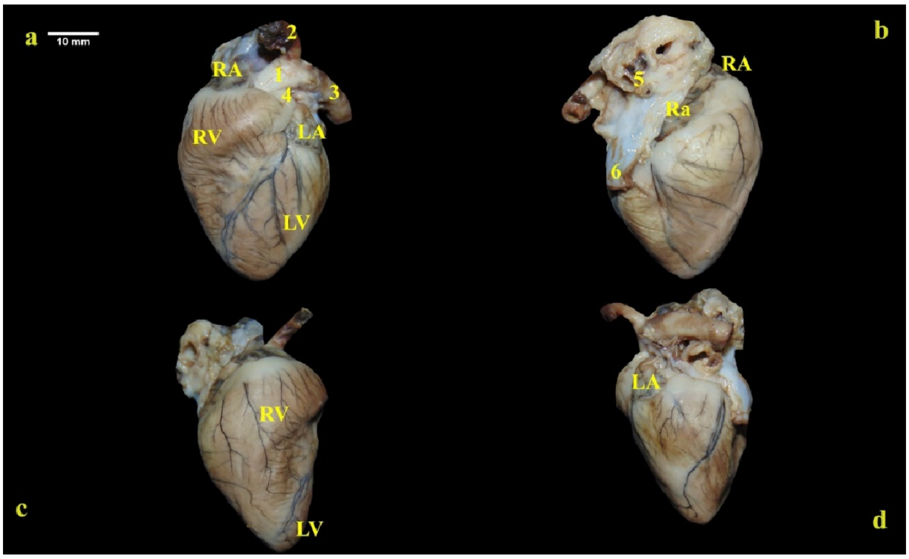

Fig. 9. A, B: The left and right sides of the heart of a mixed breed cat; **C, D:** the cranial and caudal views of the heart (formalised specimen). LA. Left auricle. LV. Left ventricle; RA. Right auricle; RV. Right ventricle; Ra. Right atrium; 1. Ascending aorta; 2. Brachiocephalic trunk; 3. Descending aorta; 4. Pulmonary trunk; 5. Pulmonary veins; 6. Caudal vena cava.

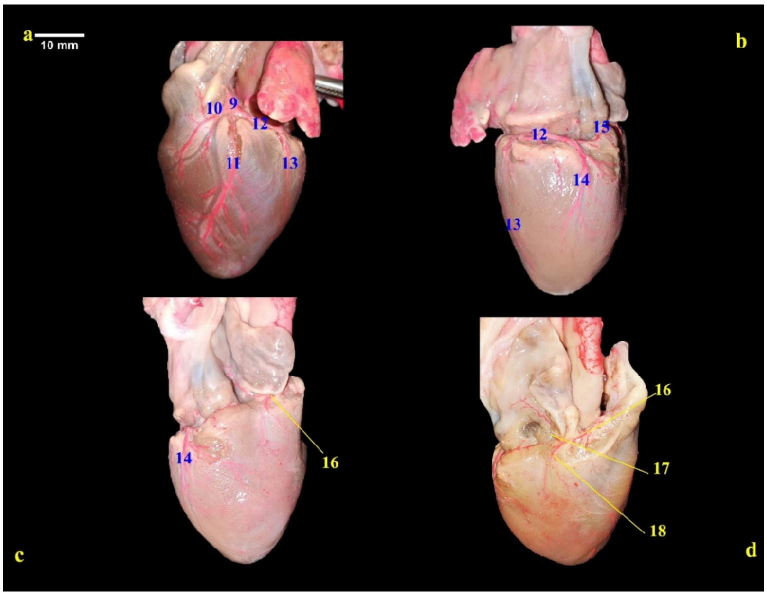

Fig. 10. A. The left side of the heart of mixed breed cat with red latex injection in coronary arteries; **B.** Caudal border of heart; **C, D:** Right side of heart. 9. Left coronary artery; 10. Septal branch; 11. Interventricular paraconal artery; 12. Left circumflex branch; 13. Diagonal interventricular branch; 14. Interventricular subsinuosal artery; 15. Terminal branch; 16. Right circumflex branch; 17. Auricular branch; 18. Ventricular branch.

till it reached the right side of heart to give interventricular subsinuosal artery and a terminal branch (Fig. 10B,C & 11B). In our cases the interventricular subsinuosal artery arose from the left coronary artery. The right coronary artery was ill developed and arose as right circumflex branch which divided into auricular and ventricular branches (Fig. 10D).

Morphometric records of cat heart demonstrated that the whole size of normal heart was 30.2±0.53 mm while the whole size of DCM heart was 43.1±0.03 mm (Table 3). The difference in size of the normal and DCM heart of cats is illustrated on Fig. 6. In normal hearts, the left ventricular wall thickness was greater than the right ventricular wall thickness (Fig. 7A); their values are shown in Table 3. In the DCM heart, the thickness of the left and right ventricular walls slightly decreased vs normal ones, in addition to the great thinning of the interventricular septum (Fig. 7B, Table 3). The left ventricular lumen of DCM hearts increased more than normal ones; also, its limit of increase was more than that of the right ventricular lumen.

DISCUSSION

Feline DCM is considered as a rare condition, although it was recorded in cats in Egypt in the present study. Regarding clinical presentation, inappetence, dyspnea and tachycardia were the most recorded signs in our findings (Hambrook & Bennett, 2012; Uppe *et al.*, 2013). Dyspnea and tachycardia in diseased cases were explained by the presence of severe degree of pulmonary effusion and manifested by significant elevation of respira-

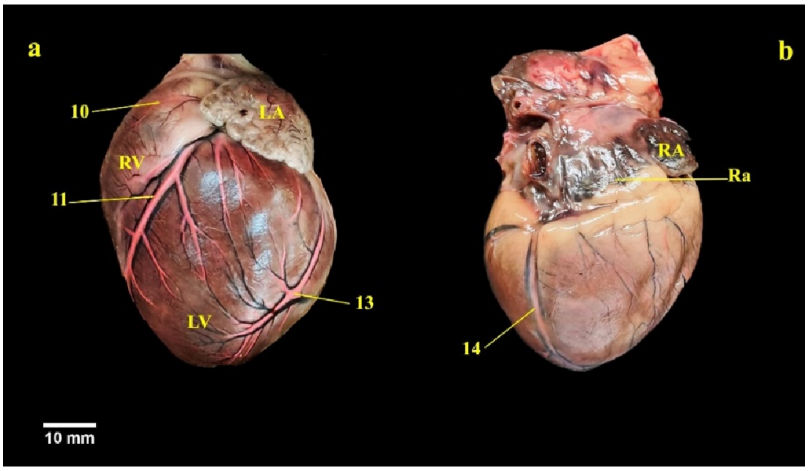

Fig. 11. Photographs showing the left (**A**) and right (**B**) sides of the heart of mixed breed cat suffering from DCM with red latex injection in coronary arteries. LA. Left auricle; LV. Left ventricle; RA. Right auricle; RV. Right ventricle; Ra. Right atrium; 1. Ascending aorta; 2. Descending aorta; 3. Pulmonary trunk; 4. Pulmonary veins; 5. Trachea; 6. Cranial vena cava; 7. Right vena azygos; 8. Caudal vena cava; 9. Left coronary artery; 10. Septal branch; 11. Interventricular paraconal artery; 12. Left circumflex branch; 13. Diagonal interventricular branch; 14. Interventricular subsinuosal artery; 15. Terminal branch; 16. Right circumflex branch; 17. Auricular branch; 18. Ventricular branch.

Table 3. Morphometric records of normal and DCM cat hearts.

Heart morphometric parameters	Control group	DCM group	P value
Left ventricular wall thickness (mm)	4.2±0.05	4.1±0.03	Not significant
Left ventricular lumen (mm)	14.6±0.44	27.2±0.39	P≤0.001
Interventricular septum thickness (mm)	5.8±0.18	2.9±0.03	P≤0.001
Right ventricular wall thickness (mm)	2.1±0.05	1.8±0.16	Not significant
Right ventricular lumen (mm)	8.7±0.14	10.6±0.33	P≤0.001
Heart thickness (mm)	30.2±0.53	43.1±0.03	P≤0.01

tory and pulse rates, chest auscultation revealed muffling sound and murmurs in some cases (Kittleson and Côté, 2021b). Regarding the feline pro-BNP test, there was an abnormal darker dot in the sample spot in all diseased conditions indicating high concentration and marked stretch in the cardiac muscles (Machen *et al.*, 2014).

In terms of radiography, the present study findings revealed marked enlargement in the hearts of cats with DCM and presence of pleural effusion (An *et al.*, 2016). Also, the heart became indefinite during radiography in cases with cardiomyopathy (Winter *et al.*, 2015) similar to findings of our study - the presence of pleural effusion produced opacity that made the heart invisible to be seen by X-ray.

Echocardiographic findings indicated a significant elevation in heart rate, LVIDd, LVIDs, and LA/AO ratio while significant decrease was recorded for fractional shortening in diseased cats compared with apparently healthy group, resembling previous records (An *et al.*, 2016; Uppe *et al.*, 2013). Left atrial enlargement had marked prognostic value when LA/AO ratio exceed 1.5 as cutoff (Cote *et al.*, 2004), the case is considered more prone to be prothrombotic (Fuentes, 2016). Decreased fractional shortening is considered a diagnostic criterion for cats with DCM (An *et al.*, 2016). Mitral and tricuspid valves regurgitation that appeared as turbulence in colour was detected in diseased cases during Doppler echocardiographic examination (An *et al.*, 2016) with high velocity (Kittleson & Côté, 2021b). The mitral valve flow velocity was greater than normal value of 120.8±32.3 cm/s similar to a previous study (Rezaian *et al.*, 1999).

Concerning the anatomical studies, they confirmed that the left cardiac notch was located at the 5th and 6th intercostal space, while the right area of auscultation was smaller, located at the 5th intercostal space (Barszcz *et al.*, 2014). The shape of normal cat heart was ovoid with a pointed apex, in contrary to previous reports that the heart was elongated (Hill and Iaizzo, 2015). This study showed that the DCM heart shape was large ovoid with rounded apex. The heart was fixed to the sternum and diaphragm by a phrenicopericardiac ligament, resembling findings in dogs (Evans & De Lahunta, 2016; Hill & Iaizzo, 2015). In contrary, in sheep it had a strong sternopericadial ligament (Hill and Iaizzo, 2015). The heart chambers in the cat heart were four, the right and left atria, and ventricles. The mitral valve opened between the left atrium and the ventricle. The tricuspid valve opened between the right atrium and the ventricle, similar to previous reports (Cochran, 2010). We added that the right and left auricles were ear-like with serrated ventral borders. The atria carried internally pectinate muscles (Cochran, 2010).

Concerning the great vessels of the cat heart, the ascending aorta gave brachiocephalic trunk and left subclavian artery (Barszcz *et al.*, 2017). On the right side of the heart appeared the cranial vena cava, right vena azygos and caudal vena cava where they drained in the right atrium similar to observations in dogs (Evans & De Lahunta, 2016; Smith, 1999); also, the pulmonary veins drained in the left atrium (Smith, 1999).

In our findings about cat vascular architecture, the ascending aorta branched into left coronary artery and right coronary artery, similar to reports in dogs (Hill & Iaizzo, 2015). The left coronary artery gave three branches; septal branch and interventricular paraconal artery, then continuing as left circumflex branch (Barszcz *et al.*, 2014; Büll & Martins, 2002). On the contrary, in some cases the septal branch arose from the interventricular paraconal branch (Barszcz *et al.*, 2014). The left coronary artery was divided into interventricular paraconal branch and left circumflex branch (Waibl *et al.*, 2012), which disagreed with our findings. Also, our data disagreed with a previous study in the Iranian native cats, stating that the left coronary artery terminated by the paraconal interventricular and circumflex branches (Monfared *et al.*, 2013). The left circumflex branched into diagonal interventricular branch, in conjunction with some cases in cats (Monfared *et al.*, 2013). Per-contra, in dog heart, the left circumflex artery branched into the auricular, ventricular and septal branches and branches to the atrio-ventricular node (Büll & Martins, 2002). In our cases that the interventricular subsinuosal artery arose from the left coronary artery, in accordance with recent reports in cats (Cochran, 2010; Monfared *et al.*, 2013) and dogs (Büll & Martins, 2002; Evans & De Lahunta, 2016).

The right coronary artery was ill developed and arose as right circumflex branch (Barszcz *et al.*, 2014). The right circumflex branch divided into auricular and ventricular branches in cats (Monfared *et al.*, 2013) and dogs (Büll & Martins, 2002). On the opposite, in horses and pigs, the right coronary artery gave the subsinuosal artery (Cochran, 2010).

In our study's morphometric records of the heart, the thickness of the left and right ventricular walls of DCM heart was slightly decreased than normal ones, in addition to the great thinning of the interventricular septum. The left ventricular lumen of DCM hearts increased more than normal ones, also its limit of increase was more than that of the right ventricular lumen. In DCM cases the internal diameter, especially the left ventricle increased (Paige *et al.*, 2009).

CONCLUSIONS

It was concluded that the most appropriate tool of diagnosis in dilated cardiomyopathy is echocardiography and Doppler ECG, in addition to the rapid test (IDEXX SNAP Feline pro-BNP test). Not all respiratory distress cases should be diagnosed as being with respiratory affection, some cases had also cardiac affections. In radiographic imaging the heart couldn't be identified clearly due to pleural effusion.

The macro-anatomical study revealed that the normal heart position was at the left and right sides extended from 5^{th} to 7^{th} rib. The shape of the normal heart of cat was ovoid with a pointed apex while the DCM heart was large, ovoid in shape with rounded apex. The whole size of the normal heart was 30.2±0.53 mm while that of the DCM heart was 43.1±0.03 mm**.** In the DCM post mortem hearts, the interventricular septum thickness was significantly thinner (P≤0.001) by 2.9±0.03 mm, and the left ventricular lumen of DCM: significantly increased (P≤0.001) by 27.2±0.39 mm.

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