10.22059/IJVM.2021.325558.1005181

Iranian Journal of Veterinary Medicine
Volume 16- Issue 1

Original Article
Online ISSN: 2252-0554

Echocardiographic Findings of Left Ventricle (LV-Study) in Cats Diagnosed with Atrial Septal Defect (ASD)

Sadaf Sadri [1], Majid Masoudifard[2*], Dariush Shirani[3]

1. *Graduated from the Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran*
2. *Department of Surgery and Radiology, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran*
3. *Department of Internal Medicine, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran*

Abstract

BACKGROUND: The severity of congenital heart disease can range from trivial to life-threatening conditions, and clinical signs might have no specific manifestation prior to sudden death. Radiographic and echocardiographic examinations of all kittens early in their lives are advisable due to the difficulties of diagnosis based on physical examination alone.

OBJECTIVES: The current study aimed to evaluate echocardiographic and radiographic findings in a group of cats with atrial septal defect (ASD) and compare their LV-study with another group of cats with normal cardiac indices.

METHODS: In the group of cats with ASD, medical records were reviewed for signalment, clinical findings, and echocardiographic data, as well as measurements in B-mode, M-mode, and color Doppler. In the normal heart group, all radiographic and echocardiographic findings were normal and echocardiographic data were compared with the same data in the group of cats with ASD.

RESULTS: We found that the shunt direction in all cats with ASD was left-to-right. The mean left atrial (LA)/aortic diameter (Ao) and IVSd were the only two LV-study parameters that were significantly higher in the group of patients than the control group. However, other LV-study parameters showed non-significant differences between these two groups. The mean IVSs, EF%, and FS% in the patients were higher than the control group, while the mean LVIDs in the group of patients was lower than the control group and the mean LVIDd, LVPWd, and LVPWs were almost the same in the two groups.

CONCLUSIONS: The results of this study showed that despite the defect in the interatrial septum of the patients, most of their left ventricular echocardiographic parameters showed no significant differences with normal references.

KEYWORDS: Atrial septal defect, Cats, Echocardiography, Left-to-right shunt, LV-study

Correspondence

Majid Masoudifard, Department of Surgery and Radiology, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran. Tel: +98 (021) 61117079, fax: +98 (021) 66933222, E-mail: mmfard@ut.ac.ir

Received: 2021-07-27

Accepted: 2021-11-05

How to Cite This Article
Sadri, F., Masoudifard, M., Shirani, D. (2022). Echocardiographic Findings of Left Ventricle (LV-Study) in Cats Diagnosed with Atrial Septal Defect (ASD). *Iranian Journal of Veterinary Medicine, 16*(1), 64-71.

Abbreviations

Ao= Aortic diameter in short axis

AR= Aortic regurgitation

ASD= Atrial septal defect

CHF= Congestive heart failure

EF %=Ejection fraction

FS%= Fractional shortening

HT= Hypertrophy

IVS= Interventricular septum

IVSd= Interventricular septum in end diastole

IVSs= Interventricular septum in maximal systole

LA= Left atrium

LVIDd= Left ventricular internal diameter in end diastole

LVPW= Left ventricular post wall

LVPWd= Left ventricular post wall thickness in end diastole

LVPWs =Left ventricular post wall thickness in maximal systole

MR= Mitral regurgitation

N= Normal

PR= Pulmonary regurgitation

RA= Right atrium

SV =Stroke volume

TR= Tricuspid regurgitation

VHS= Vertebral heart score

Introduction

Atrial septal defect (ASD) is a congenital disease characterized by the communication between the two atria owing to a defect in the interatrial septum (Thrall, 2017). Cats with severe congenital heart disease might be examined within the first days to weeks of life due to failure to thrive, dyspnea, cyanosis, or syncope. However, it is generally believed that most kittens with severe cardiovascular malformations die early in life and prior to veterinary examinations (Orton and Monnet, 2017). ASD has a prevalence of 10% among cats with congenital heart disease. In addition, the diagnosis of heart abnormalities by cardiac auscultation alone is difficult. Therefore, para-clinical examinations, such as radiography and echocardiography, are necessary to confirm the diagnosis (Tidholm *et al.*, 2015). The purpose of this study was to evaluate echocardiographic findings and compare LV-study in cats diagnosed with ASD and cats with normal heart conditions. It was hypothesized that LV-study parameters would change significantly due to ASD.

Materials and Methods

Animals

This study was performed on two groups consisting of 20 cats with ASD and 15 cats with normal cardiac indices as the control group. All cases suspicious of cardiac disease within the ASD group were physically examined and referred to the radiology department. Radiographs were taken in lateral and ventrodorsal recumbency, and samples with cardiac protrusions were recorded. Next, echocardiography was performed in the right parasternal long and short axis, and B-mode, M-mode, and Doppler parameters were assessed. Patients with interatrial defects detected in the right parasternal four-chamber view and confirmed by color Doppler were included in this study. For the normal cardiac indices group, physical examination, radiographic imaging, and echocardiographic findings showed no sign of cardiac abnormalities.

Clinical Findings

The owners of the patients diagnosed with ASD in this study had reported hyporexia, retching, coughing at night, and respiration with an open mouth. Clinical findings were absent in some cases and others showed soft, grade 2-3/6 systolic ejection murmur over the left heart base and splitting the second heart sound. Cyanosis and right-sided congestive heart failure (CHF) were absent in all cases because the defect sizes were all small.

Echocardiographic Imaging

Standard right and left parasternal short and long-axis views in M-mode and B-mode were obtained and reviewed. Short axis left atrial (LA) diameter and aortic diameter (Ao) were obtained from a 2D

right parasternal short-axis view at the point of maximal LA size (Figure 1A). A LA/Ao ratio of ≤1.5 was considered normal for this study. The left ventricular end-diastolic diameter (LVIDd) and maximal systole (LVIDs) were obtained from M-mode tracings obtained from the right parasternal short-axis view with the cursor at the level of papillary muscles.

Other systolic and diastolic measurements, such as left ventricular free wall thickness in diastole (LVPWd), interventricular septum in end-diastole (IVSd), and maximal systole (IVSs), were obtained in a similar way (Mattoon and Nyland, 2014). The remainder of the left heart measurements were retrieved from standard 2D and M-mode echocardiographic views. All 2D and M-mode assessments were made on three consecutive cardiac cycles whenever possible, and a mean was calculated (Schrope, 2013). Following the accurate measurements of described parameters, ejection fraction (%EF) and fractional shortening (%FS) were calculated using the Teichholz formula based on the measurements by the echocardiogram (Figure 2). Color Doppler imaging was used to confirm the shunts and determine their direction (Figure 3). The size of ASD was measured in all cats. The maximum size of the defect was measured in diastole from the right parasternal long-axis view (Figure 1B).

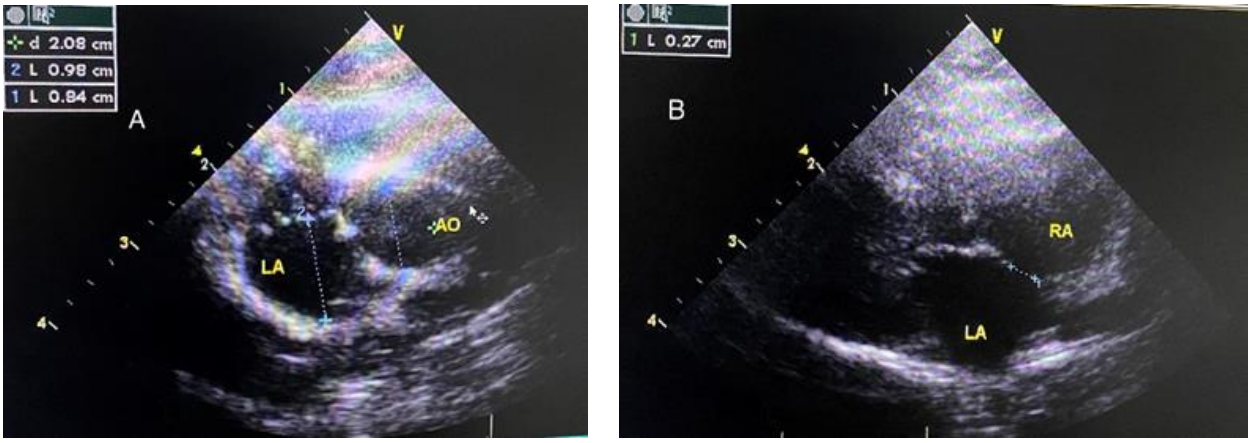

Figure 1. B-mode echocardiographic indices in right parasternal (A) measuring LA/Ao at the point of maximal LA size in short axis view in which in this case it is 1.16 (B) Assessing the defect size between right and left atria in long axis in which in this case it is 2.7mm

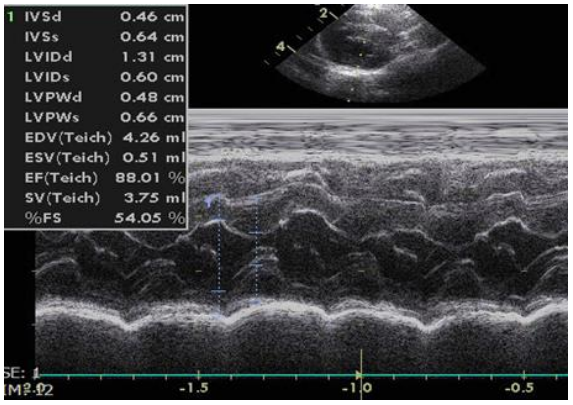

Figure 2. M-mode echocardiographic measurements at the point of left ventricle in right parasternal short axis view.

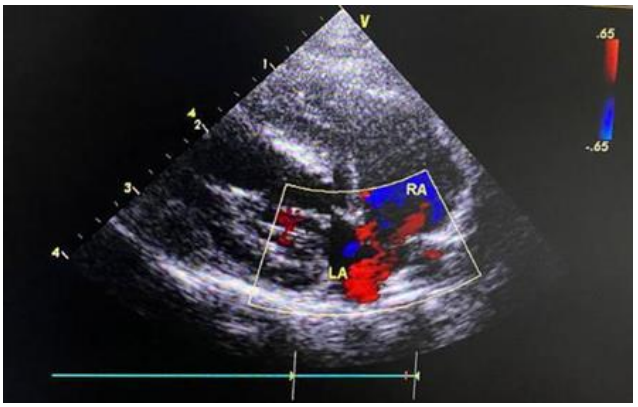

Figure 3. Color Doppler Imaging in right parasternal long axis view of ASD with left to right shunting

Radiographic Assessment

Lateral and ventrodorsal thoracic radiographs were taken (Figure 4). The vertebral heart score (VHS) was determined from a lateral view and VHS≤8 was considered normal for the present study (Kealy *et al.*, 2010). Moreover, thoracic radiographs were evaluated for the presence of cardiac protrusions and signs of CHF, including pleural effusion and pulmonary edema.

Statistical Analysis

All LV-study parameters were measured in both groups and their mean, standard deviation (SD), range, and confidence interval of 95% were calculated. Shapiro-Wilk test was used to check the normality of the data and EF% was the only parameter that did not have a normal distribution. The mean and SD of all parameters in both groups were analyzed using the SPSS 22 (SPSS Inc., Chicago, Ill., USA) and statistical comparison was performed by the Shapiro-Wilk test.

The independent samples t-test compared the parameters with normal distribution, and EF% that was not normal was compared utilizing the Mann-Whitney U test. P-value<0.05 was considered statistically significant.

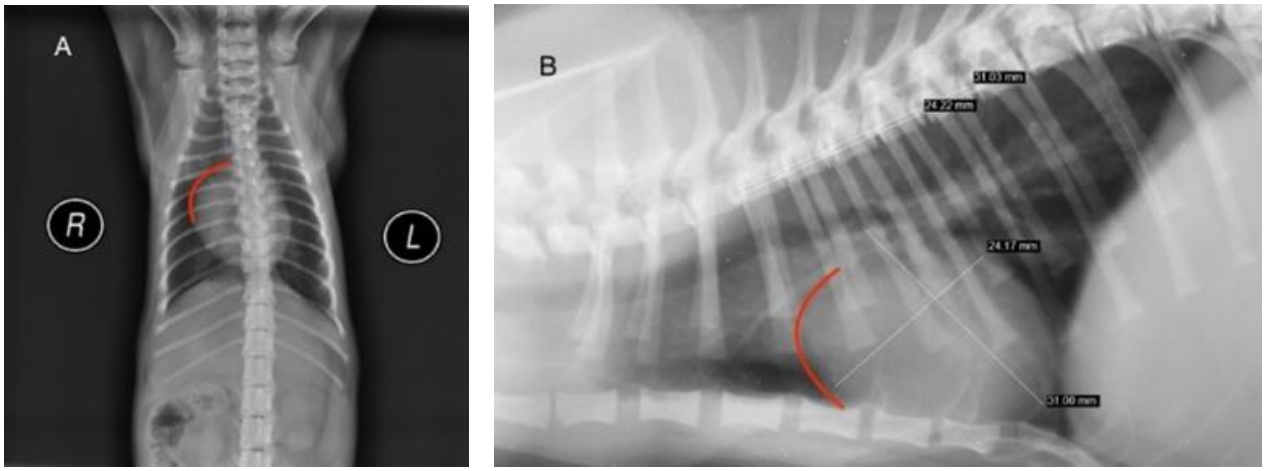

Figure 4. ASD radiographic images in (A) Ventrodorsal and (B) lateral views. VHS measured from the lateral view was 9 which indicates cardiac enlargement. Right atrial enlargement is shown with the curve lines in both views.

Results

Out of the 20 assessed cats with ASD, ten were male and ten were female. Six cats were Persian, 11 DSH, two Scottish Fold, and one mixed breed. Age at diagnosis had a range of 3-22 months. In addition, the echocardiographic parameters of 15 cats with a normal heart condition at the age range of 6-22 months were measured for comparison. In the control group, ten were male and five were female. Even cats in this group were Persian and eight cats were DSH (Table 1).

Table 1. Scattering state of the group of patients diagnosed with ASD and the control group based on sample size, age, gender and breed

Sample	Sample Size	Age (months)		Gender		Breed			
		Average	Range	Male	Female	Persian	DSH	Scottish Fold	Mixed
Cats with ASD	20	13.95	3-22	10 (50%)	10 (50%)	6/20 (30%)	11/20 (55%)	2/20 (10%)	1/20 (5%)
Control Group	15	15.75	6-22	10 (66.6%)	5 (33.3%)	7 (46.6%)	8 (53.3%)	0	0

The mean defect size was 3.19 mm and the direction of all shunts was left to right. Valvular regurgitations, mitral, tricuspid, aortic, and pulmonary were detected in color Doppler with the prevalence rate of 10% for each. In 75% of the patients, right atrial dilation and in 10% of them, right atrial dilation and right ventricular hypertrophy were detected. Furthermore, 55% of the patients had thickened IVS and LVPW (Table 2).

Although all parameters in the ASD group were within the normal reference intervals, most of them were different from the control group in terms of the mean. The mean LA/Ao, IVSd, IVSs, EF%, and FS% in patients were higher than in the control group. On the other hand, the mean LVIDs in patients was lower than the control group, and the mean LVIDd, LVPWd, and LVPWs were similar in the two groups (Table 3).

Table 2. Scattering state of B-mode study parameters in cats diagnosed with ASD

B- mode Study of The Cats with ASD												
Defect Size		Atrium/ Ventricle size			LVPW & IVS size		Valvular Condition					Shunt Direction
Average (mm)	Range (mm)	RA Dilation	RA Dilation & RV HT	N	HT	N	MR	TR	CR	AR	N	Left to Right
3.19	1.7-4.5	15/20 (75%)	2/20 (10%)	3/20 (15%)	11/20 (55%)	9/20 (45%)	2/20 (10%)	2/20 (10%)	2/20 (10%)	2/20 (10%)	14/20 (70%)	20/20 (100%)

Table 3. The mean, Standard deviation, range and confidence interval of 95% for the means of left ventricular study parameters in the group of cats diagnosed with ASD and the group of cats with normal heart condition as a control group.

	(n=15)Control Group					(n=20)Cats with ASD				
	Mean	Standard Deviation	Range	Confidence Interval of 95% for Means		Mean	Standard Deviation	Range	Confidence Interval of 95% for Means	
				Lower Band	Upper Band				Lower Band	Upper Band
Age (months)	14.7	4.25	6-21	12.3	17	14.7	4.57	7-22	12.5	16.8
LA/Ao	1.13	0.18	1-1.5	1.03	1.23	1.38	0.28	1-1.9	1.24	1.51
IVSd(cm)	0.36	0.069	0.23-0.5	0.32	0.4	0.448	0.11	0.3-0.74	0.39	0.5
IVSs(cm)	0.58	0.131	0.32-0.81	0.5	0.65	0.645	0.18	0.34-1.03	0.55	0.73
LVIDd (cm)	1.32	0.262	0.7-1.67	1.17	1.46	1.3	0.19	0.99-1.6	1.21	1.39
LVIDs (cm)	0.72	0.193	0.4-1	0.61	0.83	0.66	0.16	0.42-0.98	0.58	0.74
LVPWd (cm)	0.46	0.094	0.32-0.64	0.41	0.51	0.47	0.09	0.28-0.62	0.43	0.52
LVPWs (cm)	0.63	0.102	0.38-0.81	0.57	0.69	0.6	0.1	0.4-0.8	0.55	0.65
EF%	81.11	0.09	55.3-94	63.10	88.60	79.2	16.00	44-94	71.40	86.50
FS%	45.5	10.00	25.7-63	40.00	50.50	56.60	12.00	33-83	43.10	14.25

LA/Ao (P=0.005) and IVSd (P=0.015) were the only parameters with significant differences between the two groups of this study (Table 4). Thoracic radiographs were available for review in four cats, with all having evidence of cardiomegaly (VHS>9). Furthermore, right atrial enlargement was evident in both lateral and VD radiographic views.

Table 4. Results of the Mean Comparison Test. P-values lower than 0.05 were statistically significant and P-values higher than 0.05 were statistically insignificant.

Description	P-value
LA/AO	0.005
IVSd (cm)	0.015
IVSs (cm)	0.265
LVIDd (cm)	0.828
LVIDs (cm)	0.326
LVPWd (cm)	0.699
LVPWs (cm)	0.459
EF%	0.587
FS%	0.272

Discussion

Some cases of this study represented grade 2-3/6 systolic ejection murmur in their auscultation examination and some showed no abnormal cardiac sounds. It should be noted that feline auscultation is challenging because their apical rotation can influence the point of maximal murmur intensity and the small size of the feline thorax causes loud murmurs to radiate widely. The gradual onset of pulmonary arterial hypertension in cats can alter the character or intensity of a murmur over time with some murmurs becoming quiet or unapparent (Scansen *et al.*, 2015). All these challenges are exacerbated in kittens, causing the misinterpretation of murmurs in ASD as an innocent murmur or as one arising from mild pulmonary stenosis (Ettinger *et al.*, 2017).

Right-sided volume overload and dilation of the main pulmonary artery and its principal branches are expected with simple left-to-right shunting ASD (Block and Glassman, 2019). The LA does not enlarge because it immediately decompresses into the RA. The paradoxical motion of the IVS indicates moderate to severe volume overload (Anavekar and Oh, 2009). Shunting across an ASD can be visualized with color Doppler imaging and is predominately left-to-right. Despite the sensitivity of color Doppler imaging, establishing the presence of shunt across an ASD using only color or spectral Doppler imaging can promote false positive diagnosis.

Normal venous return to the RA is derived from cranial and caudal vena cava and the coronary sinus, which enters just dorsal to the caudal vena cava. Venous return from the caudal vena cava tracts along the atrial septum and can be readily confused with a left-to-right shunting ASD. Turbulent encoding is not often visualized in the RA because atrial pressures are so close except for an acquired ASD caused by severe MR or another cause of increased LA pressure (Penninck and d'Anjou, 2015). In order to reduce false positive results and elevate diagnostic accuracy, the evaluation of B-mode and M-mode parameters is suggested.

The right atrium, right ventricle, pulmonary artery, and left atrium are all involved in the shunt pathway of an ASD and will all be volume overloaded. The left ventricle remains unaffected by the shunt. The degree of volume overload depends on the size of the defect and the pressure difference between the left and right atrium (Boon, 2011). Large defects cause significant volume overload of the chambers and pulmonary artery and may lead to secondary tricuspid and mitral insufficiencies. In the current study, 10% of the patients had mitral regurgitation and another 10% had tricuspid regurgitation. We observed that the mean LA/Ao in patients was significantly higher than in the control group. This is potentially due to the effect of the septal defect on heart chambers, including the left atrium and its volume overload. The mean IVSd and IVSs in patients were higher than the control group, resulting from large volume overloads of the right side of the heart and increased right ventricular diastolic pressure caused by the overload. When the diastolic pressure of the right ventricle exceeds the diastolic pressure of the left ventricle, paradoxical septal movement occurs so as in diastoles, higher right ventricular diastolic pressure pushes the interventricular septum toward the left ventricle causing septal flattening.

However, left ventricular pressure exceeds right ventricular systolic pressure in systoles, and the septum is pushed upward toward the right ventricle. This paradoxical movement and volume overload result in excessive cardiac output and interventricular septum hypertrophy. The mean LVIDs in the control group were higher than the patients, but this difference was not statically significant and the mean LVIDd was the same in both groups. The insignificant difference between the mean LVIDs of patients and the control group, along with the same mean LVIDd in both groups, can be attributed to the intact condition of the left ventricle in ASDs with left-to-right shunting. The lower mean LVIDs in patients than in the control group might be caused by the increased cardiac output for pumping the excessive blood volume and lowering blood pressure in the cardiac chambers. The mean LVPWd and LVPWs in both groups showed intact left ventricle in this defect. The mean EF% and FS% in the patients were higher than the control subjects due to the augmented systolic function of the ventricles for reducing cardiac pressure and paradoxical interventricular movements. As noted earlier, the mean LVIDs in patients were lower than the control group, which too can lead to higher %EF and %FS in patients compared to the control animals. Overall, the present study shows that in ASDs with left-to-right shunting, most of the left ventricular echocardiographic parameters are not significantly different from a normal heart condition.

Conflict of Interest

The authors declared no conflict of interest.

References

Anavekar, N. S., Oh, J. K. (2009). Doppler echocardiography: a contemporary review. *Journal of Veterinary Cardiology*, *54*(3), 347-358. [DOI:10.1016/j.jjcc.2009.10.001] [PMID]

Block, C. L., Glassman, M. M. (2019). Pulmonary artery banding in a kitten with a partial atrioventricular septal defect. *Journal of Veterinary Cardiology*, *24*, 20-27. [DOI:10.1016/j.jvc.2019.05.003] [PMID]

Boon, J. A. (2011). *Congenital shunts and AV valve dysplasia. Veterinary echocardiography*. (2nd ed.). Wiley-Blackwell. Iowa, USA. p. 662-668. ISBN: 9780813823850.

Ettinger, S. J., Feldman, E. C., Cote, E. (2017). Congenital heart disease. *Textbook of Veterinary Internal Medicine*. (8th ed.). Elsevier health sciences. Missouri, USA. p. 2969-2974. ISBN: 9780323312110.

Kealy, J. K., McAllister, H., & Graham, J. P. (2010). *Diagnostic Radiology and Ultrasonography of the Dog and Cat-E-Book*. Elsevier Health Sciences. p. 295-318. ISBN: 9781437701500.

Mattoon, J. S., Nyland, T. G. (2014). Echocardiography. *Small Animal Diagnostic Ultrasound.* (3rd ed.). Elsevier Health Sciences. Missouri, USA. p. 271-291. ISBN: 9781416048671.

Orton, E. Christopher; Monnet, Eric. (2017). *Congenital Septal Defects. Small Animal Thoracic Surgery*. John Wiley & Sons. Oxford, UK. p. 211-224. ISBN: 9781416048671. [DOI:10.1002/9781118943427.ch22]

Penninck, D., d'Anjou, M. A. (Eds.). (2015). *Heart. Atlas of small animal ultrasonography*. (2nd ed.). John Wiley & Sons. Oxford, UK. p. 111-149. ISBN: 9781118359983.

Scansen, B. A., Schneider, M., Bonagura, J. D. (2015). Sequential segmental classification of feline congenital heart disease. *Journal of Veterinary Cardiology*, *17*, S10-S52. [DOI:10.1016/j.jvc.2015.04.005] [PMID]

Schrope, D. P. (2013). Atrioventricular septal defects: natural history, echocardiographic, electrocardiographic, and radiographic findings in 26 cats. *Journal of Veterinary Cardiology*, *15*(4), 233-242. [DOI:10.1016/j.jvc.2013.06.004] [PMID]

Thrall, D. E. (2017). Canine and feline thoracic wall. Textbook of Veterinary Diagnostic Radiology. (7th ed.). Elsevier Health Sciences. Missouri, USA. p. 618- 631. ISBN: 978032348247.

Tidholm, A., Ljungvall, I., Michal, J., Häggström, J., Höglund, K. (2015). Congenital heart defects in cats: a retrospective study of 162 cats (1996–2013). *Journal of Veterinary Cardiology*, *17*, S215-S219. [DOI:10.1016/j.jvc.2014.09.004] [PMID]

Iranian Journal of Veterinary Medicine
10.22059/IJVM.2021.325558.1005181
Abstracts in Persian Language
ISSN Online 2252-0554

مجله طب دامی ایران، ۱۴۰۰، دوره ۱۶، شماره ۱، ۶۴-۷۱

مطالعه یافته‌های اکوکاردیوگرافی سمت چپ قلب (LV-Study) در شانت مادرزادی دهلیزی در گربه‌ها

صدف صدری[۱]، مجید مسعودی فرد[۲*]، داریوش شیرانی[۳]

۱ دکترای عمومی دامپزشکی، دانشکده دامپزشکی، دانشگاه تهران، تهران، ایران
۲ گروه جراحی و رادیولوژی، دانشکده دامپزشکی، دانشگاه تهران، تهران، ایران
۳ گروه طب داخلی، دانشکده دامپزشکی، دانشگاه تهران، تهران، ایران

(دریافت مقاله: ۰۵ مرداد ۱۴۰۰، پذیرش نهایی: ۱۴ مهر ماه ۱۴۰۰)

چکیده

زمینه مطالعه: شدت بیماری‌های مادرزادی قلبی از خفیف تا تهدیدکنندهٔ زندگی متغیر است و ممکن است هیچ علائم بالینی خاصی در آن‌ها قبل از مرگ ناگهانی دیده نشود. با توجه به دشواری‌های تشخیص صرفاً بر اساس معاینات بالینی، توصیه می‌شود که ارزیابی‌های رادیوگرافی و اکوکاردیوگرافی بر روی تمام بچه گربه‌ها در روزهای اولیه زندگی‌شان صورت گیرد.

هدف: ارزیابی یافته‌های رادیوگرافی و اکوکاردیوگرافی در گروهی از گربه‌ها با نقص دیواره دهلیزی (ASD) و مقایسه مطالعات بطن چپ آن‌ها با گروه کنترل شامل گربه‌های با شاخص‌های قلبی طبیعی، هدف این مطالعه بود.

روش کار: در گروه گربه‌های بیمار، یافته‌های تشخیصی برای ارزیابی علائم بالینی و اندازه‌گیری‌های اکوکاردیوگرافی در مدهای روشنایی، حرکت و داپلر بررسی شدند. در گروه گربه‌های سالم معاینات بالینی، تصویربرداری رادیوگرافی و اکوکاردیوگرافی همگی نشان‌دهنده سلامت حیوان بودند و داده‌های اکوکاردیوگرافی آن‌ها برای مقایسه با همین داده‌ها در گروه بیمار استفاده شد.

نتایج: مسیر شانت در همه گربه‌های بیمار چپ به راست بود. میانگین LA/Ao و IVS تنها پارامترهای مطالعات بطن چپ بودند که در گروه بیماران از نظر آماری بیشتر از گروه کنترل بودند، اگرچه در مابقی پارامترها نیز اختلاف بین دو گروه مشاهده شد؛ اما از نظر آماری معنادار نبود. IVSs، EF ٪ و FS٪ در گروه بیماران بیشتر از گروه کنترل، LVIDs در بیماران کمتر از گروه کنترل و LVIDd، LVPWd و LVPWs تقریباً در هر دو گروه یکسان بودند.

نتیجه‌گیری نهایی: نتایج این مطالعه نشان داد که علیرغم نقص دیواره بین دهلیزی، اکثر پارامترهای اکوکاردیوگرافی سمت چپ قلب تغییر معناداری نشان نمی‌دادند.

واژه‌های کلیدی: اکوکاردیوگرافی، شانت چپ به راست، گربه‌ها، نقص دیواره بین دهلیزی

نویسندهٔ مسئول: ایران، تهران، خیابان دکتر قریب، دانشکده دامپزشکی دانشگاه تهران. تلفن: ۰۲۱۶۱۱۱۷۰۷۹ نمابر: mmfard@ut.ac.ir