

## Evaluation of Radiographical, Echocardiographical and Color-Doppler Findings of Heart Diseases in Geriatric Dogs

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**Abstract:** In this study, 30 geriatric dogs of different breeds, ages, and sex (15 females, 15 males) with suspected heart diseases were evaluated. All dogs were examined clinically, radiographically, and ultrasonographically.

Thoracic radiography revealed cardiomegaly in 5 cases, right atrial dilatation in 7 cases, right ventricular dilatation in 5 cases, left atrial dilatation in 1 case, and left ventricular dilatation in 2 cases. 2-D echocardiography permitted direct visualization of pericardial effusion in 4 cases, cardiac hypertrophy in 1 case, right atrial dilatation in 1 case, vegetative mass lesion in 1 case, and cardiomegaly in 2 cases. Color Doppler Imaging were revealed mitral valve insufficiency in 6 cases, tricuspid valve insufficiency in 2 cases, and atrial septal defect (ASD) in 1 case. In conclusion, for the reliable diagnosis of the heart diseases, radiographical, echocardiographical, and color-Doppler examinations must be performed systematically. Radiographical examinations provide limited information especially intracardiac disorders, and it is possible to learn more about the intracardiac disorders and degenerative valve lesions are defined clearly by echocardiography and color Doppler examinations.

**Key Words:** Radiography, echocardiography, color Doppler, heart, geriatric dog

### Geriatrik Köpeklerde Kalp Hastalıklarında Radyografik, Ekokardiografik ve Renkli Doppler Muayene Bulgularının Değerlendirilmesi

**Özet:** Bu çalışmada, kalp hastalıklarından şüphelenilen farklı ırk, yaş ve cinsiyette 30 geriatrik köpek değerlendirilmiştir. Tüm köpeklerin klinik, radyografik ve ekokardiografik olarak muayeneleri yapılmıştır.

Toraks radyografisi 5 olguda kardiomegalinin, 7 olguda sağ atrial dilatasyonun, 5 olguda sağ ventriküler dilatasyonun, 1 olguda sol atrial dilatasyonun, ve 2 olguda da sol ventriküler dilatasyonun ortaya çıkarılmasını sağlamıştır. 2-D ekokardiografik muayene ile 4 olguda perikardial sıvı birikiminin, 1 olguda kalp hipertrofinin, 1 olguda sağ atrial dilatasyonun, 1 olguda kitlesel lezyonun ve 2 olguda da kardiomegali tanımlanmıştır.

Sonuç olarak; kalp hastalıklarının güvenilir tanısı için radyografik, ekokardiografik ve renkli Doppler muayene teknikleri birlikte kullanılmalıdır. Radyografik muayeneler özellikle kalp içi lezyonlarda sınırlı bilgiler sağlamaktadır. Ekokardiografik ve renkli Doppler muayeneleri ile dejeneratif kapak lezyonları açıkça belirlenmekte ve kalp içi lezyonlar hakkında daha fazla bilgi sağlanmaktadır.

**Anahtar Sözcükler:** Radyografi, ekokardiografi, renkli Doppler, kalp, geriatrik köpek

### Introduction

Cardiac diseases are common in the geriatric animals and frequently leads to clinical problems. The owner may recognize cardiac dysfunction that results in lethargy, coughing, dyspnea, or syncope. The veterinarian can often diagnose asymptomatic cardiac disease by physical examination, electrocardiography, and a complete blood profile (1,2).

Chronic valvular heart disease is the most common geriatric cardiac disorder (1,2). These problems frequently lead to exercise intolerance. Other types of cardiac disease may be recognized. These include heart failure, secondary to cardiomyopathy, arrhythmias, heartworm disease, pericardial disease, and infective endocarditis (2). Dilation of the left atrium and left ventricle in cardiomyopathy and congenital heart disease can result in secondary atrioventricular valvular

insufficiency. Acquired valvular heart disease can also be associated with bacterial endocarditis. Mitral valvular insufficiency is a rare condition that can occur secondary to heartworm disease (2,3).

Mitral valvular regurgitation is a common cause of left-sided heart failure (4). Ascites and other clinical signs of right ventricular failure often seem to be secondary to left-sided heart failure. Mitral valvular degeneration is sometimes associated with ruptured chordae tendinae and left atrial tear. Acute congestive heart failure is the result. Right-sided failure is most likely related to the increased pressure work necessary to pump blood against a hypertensive pulmonary venous circulation. In some dogs with severe tricuspid valvular degeneration, severe right ventricular failure can develop (2,5).

Most diseases that cause dilation or hypertrophy of the heart affect two or more chambers. Mitral valve insufficiency leads to both left ventricular and left atrial enlargement; pulmonic valve stenosis causes right ventricular enlargement; a main pulmonary artery bulge, and often right atrial dilation. Nevertheless, enlargement of specific chambers and great vessels is described individually (3).

A complete geriatric profile for diagnosing cardiovascular disease includes history, physical examination, thoracic radiography, electrocardiography, echocardiography, and analysis of blood, urine, and extravascular fluids. This complete database is important in individualizing medical management of clinically significant cardiac diseases, especially before any anesthetic procedure. All special diagnostic tests may be necessary for certain types of cardiac disorders (6-8).

Thoracic radiography continues to play an important role in the assessment of patients with heart disease or heart failure. At least two radiographic views of the chest should be evaluated: lateral and dorsoventral (DV) or ventrodorsal (V/D) (7,9).

The radiographic signs of chronic mitral valvular degeneration vary according to the severity of the condition. Usually, the first chamber to enlarge is the left atrium. With marked enlargement of the left atrium, compression of the left main stem bronchus may occur. Left ventricular enlargement and hypertrophy occurs as a compensation for the mitral valvular regurgitation. Right ventricular enlargement is common and results from tricuspid regurgitation, pulmonary venous hypertension

from mitral regurgitation, or concurrent chronic obstructive pulmonary disease. In left ventricular failure, there is pulmonary venous distension and pulmonary edema. In right ventricular failure, there is pleural effusion, enlargement of the caudal vena cava, ascites, and, frequently, hepatomegaly (9).

Cardiac ultrasonography (echocardiography) is becoming widely available and more sophisticated as a noninvasive tool for imaging the heart and surrounding structures. It is used to evaluate cardiac chamber size, wall thickness, wall motion, valve configuration and motion, and the proximal great vessels. Using ultrasound, anatomic relationships can be determined, and information on cardiac function can be derived. This technique provides a sensitive method for detecting pericardial and pleural fluid accumulation and can allow identification of mass lesions within and adjacent to the heart. Most examinations can be completed with minimal or no chemical restraint (10-12).

Doppler imaging allows evaluation of blood flow patterns and velocity, permitting documentation and quantification of valvular insufficiency or stenosis and cardiac shunts. Estimation of blood flow and cardiac output can also be made. Three types of Doppler echocardiography are used clinically; pulsed wave (PW), continuous wave (CW), and color Doppler. Color flow mapping is a form of PW Doppler ultrasonography that combines 2-D modality with blood flow imaging. Most systems code blood flow toward the transducer as red and flow away as blue. Differences in relative velocity of flow can be accentuated, and the presence of multiple velocities and directions of flow (turbulence) can be indicated by different maps that use variations in brightness and color (3,13-15).

The aim of this study were to investigate the use of radiographical, echocardiographical, and color-Doppler examination techniques in the diagnosis of the cardiac disorders in geriatric dogs; to determine the extend of intracardiac lesions using echocardiography and color-Doppler examination.

## Materials and Methods

Thirty geriatric dogs of different breeds, ages, and sex (15 females, 15 males) with suspected heart diseases were evaluated. Mean age of the subjects was 10.2 yr (range 7 to 14). The study population consisted of 15

Terrier, 3 American cocker, 3 mix breed, 3 Poodle, 1 Anatolian sheepdog, 1 Boxer, 1 Great dane, 1 Pointer, 1 Doberman, and 1 Basset hound. All dogs were examined clinically, radiographically, and ultrasonographically.

All radiographic examinations were performed using a Shimadzu (30 mA) Radiographic Unit. 2-D echocardiographic and color Doppler imaging was performed using a commercially available system (ESAOTE AU5, ESAOTE BIOMEDICA; Via Siffredi 58; 16 153 Genova, Italy) with a 3.5 to 5.0 MHz multiply frequency sector probe.

Information on clinical manifestations, including appetite, exercise and respiratory abnormalities, was collected from the dogs' owners. Based on this information, each case was evaluated radiographically, echocardiographically, and color Doppler imaging. All dogs were examined thoracic radiography on L/L and V/D position.

The hair coat over the left and right ventral hemithoraces was saturated in turn with 70% ethyl alcohol and a commercial acoustic coupling gel over the areas where the transducer was expected to contact the chest wall. All dogs underwent a complete transthoracic 2-D echocardiographic and color Doppler imaging examination using an Doppler ultrasound system and a transducer array of 3.5 or 5.0 MHz, depending on size of the animal. Echocardiographic examinations were performed from both left and right parasternal location, using manual restraint only. By setting the echo window at the middle between the sternal border and the costochondral junction of the left 3<sup>tr</sup> and 4<sup>th</sup> intercostal spaces, images of the long axis view were obtained and used for this study. The mitral and tricuspid valves were imaged on the left and right parasternal long axis view and left apical four-chamber or five-chamber view. 2-D echocardiography permitted direct visualization of cardiac hypertrophy, cardiac mass lesion, mitral and tricuspid valve dysplasia, and pericardial effusion (PE).

For Doppler color flow imaging (CFI) distribution, the transducer was placed at angles which allowed extensive CFI display of the bluish area representing the mitral and tricuspid regurgitation jet signal near the mitral and tricuspid orifice during the systolic phase, including CFI distribution of the left and right ventricle side of the valves, as well as the mosaic area of the regurgitation jets. The echocardiography machine was set as follows: color Doppler pulse repetition frequency (PRF), 5-10

KHz, which allowed measurement of velocities up to 76.9 cm/s; frame rate (FR), 13-24 frame/s; color gain, from 11-22. In CFI, the maximum area of distribution of insufficiency signals at the mitral and tricuspid orifice was evaluated.

## Results

All geriatric dogs were presented with past histories of exercise intolerance and dyspnea. All geriatric dogs were auscultated and had radiograms and echocardiograms recorded. Physical examination findings included dyspnea, muffled heart sounds, and extreme weakness. Thoracic radiography revealed cardiomegaly in 5 cases, right atrial dilatation in 7 cases, right ventricular dilatation in 5 cases, left atrial dilatation in 1 case, and left ventricular dilatation in 2 cases.

2-D echocardiography permitted direct visualization of PE in 4 cases, cardiac hypertrophy in 1 case, right atrial dilatation in 1 case, vegetative mass lesion in 1 case, and cardiomegaly in 2 cases.

Color Doppler Imaging were revealed mitral valve insufficiency in 6 cases, tricuspid valve insufficiency in 2 cases, and atrial septal defect (ASD) in 1 case (Table).

In 5 of the geriatric dogs with cardiomegaly, radiographic evaluation of the heart on L/L and V/D views were showed generalized cardiomegaly, biventricular and biatrial enlargement, and deviation of tracheal elevation over the dorsal part of the thorax (Figure 1). In 1 of the geriatric dogs with left atrial dilatation, radiographic evaluation of the heart on L/L and V/D views were determined a bulge in the 2 to 3 o'clock position and deviation of tracheal elevation over the dorsal part of the thorax. In 2 of the geriatric dogs with left ventricular dilatation, radiographic evaluation of the heart on L/L and V/D views were defined the caudal heart border became convex. There is rounding and enlargement approximately in the 3 to 5 o'clock position. In 7 of the geriatric dogs with right atrial dilatation, radiographic evaluation of the heart on L/L view was determined a bulge of the cranial heart border on lateral projection, with widening of the cardiac silhouette (Figure 2). Tracheal elevation was seen over the dorsal part of the thorax. Bulging of the cardiac shadow on V/D view was occurred in the 9 to 11 o'clock position. In 5 of the geriatric dogs with right ventricular dilatation, radiographic evaluation of the heart on L/L view was

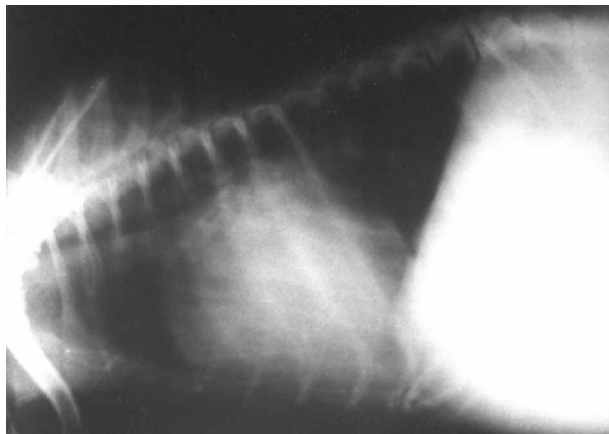
Table. Geriatric dogs with atrioventricular valve dysplasia determined by color Doppler imaging.

Case no	Breed	Age	Sex	Diagnosis
3	Cyprus Terrier	11 yr	M	MVI 3°, TVI 2°
7	Terrier	8 yr	F	MVI 2°
11	Terrier	11 yr	M	MVI 2°
17	Poodle	11 yr	M	MVI 1°
18	Terrier	10 yr	F	MVI 3°
24	Terrier*	11 yr	F	MVI 1°, TVI 2°
30	Poodle	9 yr	M	TVI 1°

\* dog with ASD

MVI: mitral valve insufficiency

TVI: tricuspid valve insufficiency



(A)

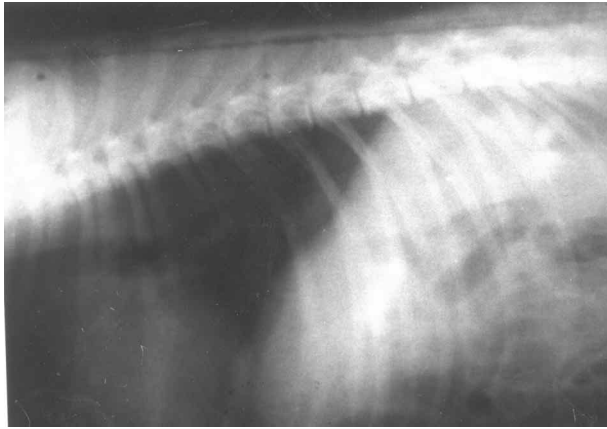


(B)

Figure 1. Lateral (A) and dorsoventral (B) radiographs from a geriatric dog with cardiomegaly. Note globoid shape of cardiac silhouette.

defined increased convexity of the cranioventral heart border and elevation of the trachea over cranial heart on the lateral view (Figure 3). With severe right ventricular enlargement and relatively normal left heart size the apex was elevated off the sternum. The heart on V/D view was tended to take on a “reserve D” configuration. The apex was shifted leftward, and right heart border bulges to the right.

In 4 of the geriatric dogs with PE, owing to pericardial sac filled fluid, were defined cardiac contours tended the obliterate and create had a globoid heart shadow on L/L and V/D views. In same cases, echocardiographic evaluation of the heart were recognized an anechoic space between the epicardium and the pericardium (Figure 4). The anechoic effusion was surrounded the heart within the pericardium.

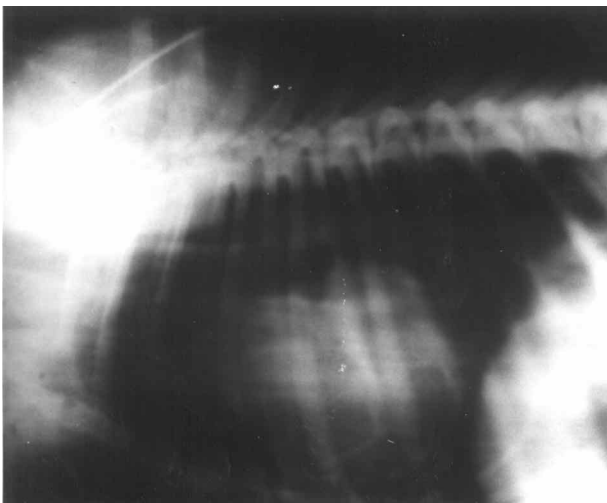


(A)

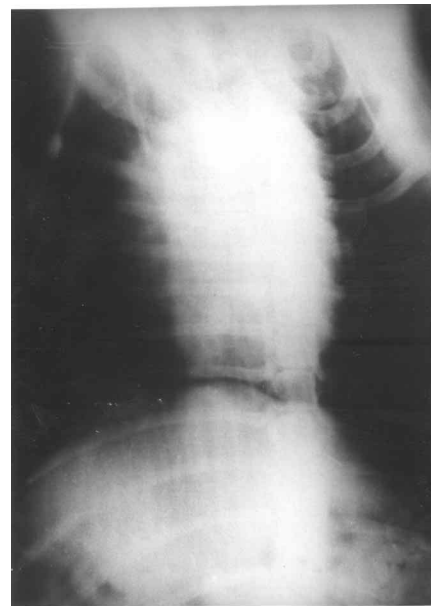


(B)

Figure 2. Lateral (A) and dorsoventral (B) radiographs from a geriatric dog with right atrial dilatation (tracheal elevation on lateral view and reverse D configuration on V/D view).



(A)



(B)

Figure 3. Lateral (A) and dorsoventral (B) radiographs from a geriatric dog with right ventricular dilatation (apex elevation and increased convexity of the cranioventral heart border on lateral view).

In 1 of the geriatric dogs with cardiac hypertrophy, 2-D echocardiographic evaluation of the heart defined extreme hypertrophy of the myocardium. The extent and

distribution of hypertrophy was variable, and it was global, and asymmetric septal hypertrophy. In 1 of the geriatric dogs with right atrial dilatation, 2-D



Figure 4. Pericardial effusion in a geriatric dog. A large quantity of fluid surrounds the heart. (PE: Pecardial effusion, PLE: Pleural effusion, LV: Left ventricle, LA: Left atrium).



Figure 5. Vegetative mass lesion in a geriatric dog. In this case, a smooth, hypochoic mass can be seen in the right atrium. (RV: Right ventricle, RA: Right atrium, LA: Left atrium, V: Vegetative mass).



Figure 6. Mitral valve regurgitation in a geriatric dog. This image demonstrating a relatively wide origin jet crosses the mitral valve and enters the left atrium. The flow pattern is coded as mosaic color, especially across the valve leaflets. (LV: Left ventricle, LA: Left atrium, MV: Mitral valve).

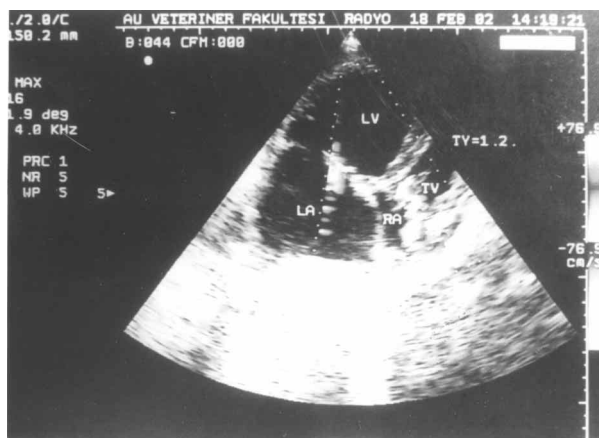


Figure 7. Tricuspid valve regurgitation in a geriatric dog. This image demonstrating a relatively wide origin jet crosses the tricuspid valve and enters the right atrium. The flow pattern is coded as mosaic color, especially across the valve leaflets. (RA: Right atrium, TV: Tricuspid valve, LV: Left atrium, LA: Left atrium).

echocardiographic evaluation of the heart on left parasternal long axis view recognized dilatation of atrium. In 1 of the geriatric dogs with vegetative mass lesion, 2-D echocardiographic evaluation of the heart depicted hypochoic mass in the right atrium (Figure 5). In 1 of the geriatric dogs with cardiomegaly, 2-D echocardiographic evaluation of the heart was marked dilation of both left atrium and left ventricle.

Mitral valve regurgitation (6 cases) and tricuspid valve regurgitation (3 cases) were detected in geriatric dogs by

color Doppler echocardiography. The regurgitant jet of color-coded patterns originated at the center of coaptation of the mitral and tricuspid valve (Figure 6 and 7). These patterns indicate that the peak velocity of regurgitant signals measured by color Doppler echocardiography was below 76.9 cm/s. In 1 of the geriatric dogs with ASD, color Doppler echocardiographic evaluation of the heart was visualized during systole to permit left to right shunting, which is coded mosaic color.

## Discussion

Cardiac disorders are a common problem in geriatric dogs. It can be seen in every dog breed at every sex and geriatric age. Many researchers report that geriatric dogs with cardiac disorders are presented lethargy, coughing, dyspnea or syncope (1,2). In this study, with anamnesis from the animals' recognized owners and clinical examination findings 30 geriatric dogs with suspected cardiac disorders were evaluated.

It is reported that various cardiac disorders occur in geriatric dogs. These include heart failure, secondary to cardiomyopathy, arrhythmias, heartworm disease, pericardial disease, degenerative valvular diseases, and infective endocarditis. These problems frequently lead to exercise intolerance (1,2). In present study, geriatric dogs were determined to have cardiomegaly, atrial and ventricular dilatation, PE, vegetative mass lesion, ASD, and degenerative valve dysplasia.

It is announced that degenerative valvular disease is the most common cardiovascular lesion of the dog. It is also major cause of heart failure in older dogs. The valvular lesions are termed endocardiosis. Atrioventricular valvular insufficiency is a clinical term that refers to a functional abnormality of the atrioventricular valve leaflets that results in regurgitation of the blood from the ventricle into the atrium during ventricular systole. The term regurgitation or incompetence can be used for the term insufficiency (3-5). In cases, atrioventricular valve degeneration were defined in heart with color Doppler echocardiography. In 6 cases, mitral valve was defined as dysplastic due to chronic degeneration and turbulence flow (mosaic color) was seen in valve orifice. In 3 cases, tricuspid regurgitant flow were determined enters the valve orifice. This flow pattern was coded as turbulent, especially across the valve leaflets.

Various studies have estimated the overall incidence of mitral valve insufficiency as from 8% to 42%. Males are affected more often than females. Small breeds have a higher incidence than large-breed dogs. Approximately one third of dogs have both mitral and tricuspid valvular disease (2). In this study, incidence of mitral valve insufficiency was determined 20% in geriatric dogs with suspected cardiac disease. Males were affected more often than females (4 males, 3 females). Small breeds had a higher incidence than large-breed dogs (all cases were small breed). One third of dogs had both mitral and

tricuspid valvular disease (in 2 cases with both valve insufficiency).

For the decision of diagnosing cardiovascular disease, individualizing medical management, and especially before any anesthetic procedure, the use of history, physical examination, thoracic radiography, electrocardiography, echocardiography, and analysis of blood, urine, and extravascular fluids are necessary (6-8). In this research, all geriatric dogs with suspected cardiac disorders were examined radiographically, echocardiographically, and color Doppler echocardiographically.

It is reported that approximately 25% of heart disease in dogs occur between the ages of 9 and 12, and 33% in dogs 13 years and older (2). In this study, 27 dogs with ages between 7-12 (90%), and 3 dogs with ages 13 or older (10%) were decided to have cardiac disorders.

Thoracic radiography continues to play an important role in the assessment of patients with heart disease or heart failure. At least two radiographic views of the chest should be evaluated: lateral and dorsoventral (DV) or ventrodorsal (V/D) (7,9). In this study, on L/L and V/D radiographic views of heart was examined size, shape, and localization like various respects in the thorax.

Generalized enlargement of the heart shadow on plain thoracic radiographs can indicate true cardiomegaly or distention of the surrounding pericardial sac. When the heart it self is enlarged, the contours of different chambers are evident, although massive right ventricular and atrial dilation can make the heart appear very round. Filling of the pericardial sac with fluid, fat, or viscera tended to obliterate these contours and create a globoid heart shadow (7,8). In 5 cases with cardiomegaly were defined biventricular and biatrial enlargement, and deviation of tracheal elevation over the dorsal part of the thorax. In dogs with PE, owing to pericardial sac filled fluid the defined cardiac contours tended to obliterate and create a globoid heart shadow on L/L and V/D views.

Most diseases that caused dilation or hypertrophy of the heart affected two or more chambers. D/V or V/D views demonstrated a bulge in dogs (7-9). In this study, V/D views of heart were examined. Cardiac chambers enlargement led to in this views according to clock face position. In 1 case with left atrial enlargement there was a bulge in the 2 to 3 o'clock position; in 2 cases with left

ventricular enlargement there was a rounding in the 3 to 5 o'clock position; in 7 cases with right atrial enlargement there was a bulge in the 9 to 11 o'clock position; and in 5 cases with right ventricular enlargement there was seemed a reverse "D" configuration.

It is reported that echocardiography has become widely available and is more sophisticated as a noninvasive tool for imaging the heart and surrounding structures. It is used to evaluate cardiac chamber size, wall thickness, wall motion, valve configuration and motion, and the proximal great vessels (10-12). In this study, using ultrasound, anatomic relationships were determined between intracardiac structures and information on cardiac function was derived. Echocardiographic examinations detected pericardial fluid accumulation and allowed identification of mass lesions within the heart.

It is stated that Doppler imaging allows evaluation of blood flow patterns and velocity, permitting

documentation and quantification of valvular insufficiency or stenosis and cardiac shunts. Estimation of blood flow and cardiac output can be performed (3,13-15). Using color Doppler imaging, the mitral and tricuspid regurgitation jet signal was defined near the mitral and tricuspid orifice during the systolic phase, including CFI distribution of the left and right ventricle side of the valves, as well as the mosaic area of the regurgitation jets. Also changes of blood flow hemodynamics were determined in ASD.

In conclusion, for the reliable diagnosis of heart diseases, radiographical, echocardiographical, and color-Doppler examinations must be performed systematically. Radiographical examinations provide limited information especially on intracardiac disorders, and it is possible to learn more about the intracardiac disorders and to define degenerative valve lesions clearly by echocardiography and color Doppler examinations.

## References

1. Bonagura, J.D.: Cardiopulmonary disorders in the geriatric dog. *Vet. Clin. North Am. Small Anim. Pract.*, 1981; 11: 705.
2. Miller, M.S., Tilley, L.P., Smith, F.W.K.: Cardiopulmonary disease in the geriatric dog and cat. *Vet. Clin. North Am. Small Anim. Pract.*, 1989; 19: 87-102.
3. Bonagura, J.D., Miller, M.V., Darke, P.G.G.: Doppler echocardiography. *Vet. Clin. North Am. Small Anim. Pract.*, 1995; 28: 1325-1389.
4. Tilley, L.P.: Acquired Valvular Heart Disease. In: Tilley, L.P., Owens, J.M., Eds. *Manual of Small Animal Cardiology*. Churchill Livingstone, Oxford, 1985; 115-128.
5. Appleton, C.P., Basnight, M.A., Gonzalez, M.S.: Diastolic mitral regurgitation with atrioventricular conduction abnormalities: relation of mitral flow velocity to transmitral pressure gradients in conscious dogs. *J. Am. Coll. Cardiol.*, 1991; 18: 843.
6. Dodman, N.H., Seeler, D.C., Court, M.H.: Aging changes in the geriatric dog and their impact on anesthesia. *Compend. Contin. Ed. Pract. Vet.*, 1984; 6: 1106.
7. Ware, W.A.: Disorders of the Cardiovascular System. In: Nelson, R.W., Couto, C.G., Eds. *Essentials of Small Animal Internal Medicine*. Mosby Year Book, St. Louis, 1992; 114-121.
8. Sisson, D.D., Thomas, W.P., Bonagura, J.D.: Congenital Heart Disease. In: Ettinger, S.J., Feldman, E.C., Eds. *Text Book of Veterinary Internal Medicine*. WB Saunders Company, Philadelphia, 2000; 737-786.
9. Burk, R.L., Ackerman, N.: *Small Animal Radiology and Ultrasonography*. WB Saunders Company, Philadelphia, 1996; 44-58.
10. Bonagura, J.D.: Echocardiography. *J. Am. Vet. Med. Assoc.*, 1994; 204: 516-522.
11. Barr, F.: *Diagnostic Ultrasound in the Dog and Cat*. Blackwell Science, Edinburgh, 1990; 115-149.
12. Kienle, R.D., Thomas, W.P.: Echocardiography. In: Nyland T.G., Mattoon, J.S., Eds. *Veterinary Diagnostic Ultrasound*, WB Saunders Company, Philadelphia, 1995; 198-254.
13. Burns, P.N., Jaffe, C.C.: Quantitative flow measurements with doppler ultrasound: techniques, accuracy, and limitations. *Radio. Clin. North Am.*, 1985; 23: 641-657.
14. Uehara, Y., Takahashi, M.: Quantitative evaluation of the severity of mitral-insufficiency in dogs by the color doppler method. *J. Vet. Med. Sci.*, 1996; 58: 249-253.
15. Kibar, M.: *Doppler Echocardiographic Examination of Atrioventricular Valves in Dogs*, PhD dissertation. University of Ankara, Ankara, Turkey. 2002.