Kafkas Univ Vet Fak Derg
15 (5): 751-757, 2009
DOI:10.9775/kvfd.2009.101-A

RESEARCH ARTICLE

The Evaluation of Echocardiographic Findings on Sports Horses

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Makale Kodu (Article Code): 2009/101-A

Summary

The aim of this study was to evaluate the findings of blood hemodynamics, left ventricular contractility, internal diameter of the left ventricle and atrium, aort and atrioventricular valve function disorders in the sport horses (n = 79). The anatomical structure and blood hemodynamics of atrioventricular (AV) valves, measurements of cardiac structure were determined using M-mode, 2-D, pulsed-wave (PW) and color Doppler findings obtained from the right and left chest wall in the 3,4 and 5 chamber views. In 42 horses without cardiac diseases findings, average interventriculer septum thickness in diastole and systole was 32.3±5 and 41.4±7 mm; left ventricular internal diameter in diastole and systole, 122.3±6 and 74±4 mm; left ventricular free wall thickness in diastole and systole, 26.9±4 and 34.8±8 mm; aortic internal diameter, 88.1±6 mm; left atrium internal diameter, 63.1±3 mm and fractional shortening, 40.4±5%. Of 37 horses diagnosed with cardiac diseases, 7 horses had left atrioventricular dilatation; 5 had left atrial dilatation; 3 had low fractional shortening (19-28%); 10 had regional hypokinesia on left ventricular free wall and 7 had pericardial effusion as well as in 5 cases, the E:A ratio was below 1. In conclusion, this screening study reveals importance of echocardiographic parameters in detection of cardiac diseases without exhibiting major clinical symptoms.

Keywords: *Cardiac diseases, Echocardiography, Horses*

Spor Atlarında Ekokardiyografik Bulguların Değerlendirilmesi

Özet

Bu çalışmanın amacı, spor atlarında (n = 79) kan hemodinamiği, sol ventrikül kontraktibilitesi, sol ventrikül ve atrium iç çaplarını, aort ve atrioventriküler kapakların fonksiyon bozukluklarını değerlendirmekti. Atrioventriküler (AV) kapakların anatomik yapısı ve kapak düzeyindeki kan hemodinamiği, kardiak yapıların ölçümleri, göğüs kafesinin sağ ve sol tarafından belirlenen 3,4,5 odacık görüntüsünde M-mod, 2-D görüntüleme, pulsed-wave (PW) ve renkli Doppler ile elde edilen bulgular doğrultusunda değerlendirme yapıldı. Kardiak hastalık bulgusu olmayan 42 atta, interventriculer septum kalınlığı diyastolde 32.3±5 mm ve sistolde 41.4±7 mm; sol ventriküler iç çap diyastolde 122.3±6 mm ve sistolde 74±4 mm; sol ventriküler serbest duvar kalınlığı diyastolde 26.9±4 mm ve sistolde 34.8±8 mm; aortik iç çap 88.1±6 mm; sol atriumun iç çapı 63.1±3 mm; fractional shortening % 40.4±5 ortalama değerleri elde edildi. Kardiak hastalık tanısı konulan 37 atın 7'sinde sol atrioventriküler dilatasyon, 5'inde sol atrial dilatasyon, 3'ünde azalmış fractional shortening (19-28%); 10'unda sol ventriküler serbest duvarda regional hipokinezi. 7'sinde perikardial effüzyon ve 5 olguda da E:A oranı 1 değerinin altında belirlendi. Sonuç olarak, bu saha çalışması, belirgin klinik semptomları olmayan kardiak hastalıkların belirlenmesinde ekokardiografik parametrelerin önemini ortaya koymaktadır.

Anahtar sözcükler: *Kardiyak hastalıklar, Ekokardiyografi, At*

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INTRODUCTION

Echocardiography is one of the main techniques used in assessing heart function and morphology of horses. M-mode and two-dimensional (2-D) echocardiography may be quantitively employed in the process of measuring the volume of cardiac structures and cardiac function. The use of color Doppler, together with 2-D echocardiography, enables the assessment of valve function [1]. The speed of the blood stream at the level of the aorta and pulmonary artery may be measured by (PW) Doppler. These echocardiography techniques may be used for diagnosing cardiac diseases in horses [2-6]. Dilated cardiomyopathy may be determined in dilatations of left ventricle and atrium by echocardiography [7]. In assessing hypertrophic cardiomyopathy, left ventricular wall, interventricular septum, and the systolic and diastolic increase of myocardial thickness are measured in asymmetrical septal hypertrophy and abnormal movement of the front mitral valve [8].

In this study on sport horses, we aimed at evaluating the left ventricle and atrium measurements, the contractibility of the left ventricle, the functional disorders related to the atrioventricular and aortic valves, and the findings with regard to the blood hemodynamics by means of M-mode, 2-D imaging, and Doppler echocardiographic examinations.

MATERIAL and METHODS

The study subjects were 79 (42 horses without cardiac diseases findings and 37 horses with diagnosed cardiac diseases) horses of various breeds from several organizations in Ankara and Nevşehir. The ages of the horses ranged from 5 to 13 years and their live weights were between 470 and 640 kg. An ESAOTE utra-sonography device, model AU5 (ESAOTE BIOMEDICA, Genova, Italy) with a 2.5 MHz sector prop, was used for the Doppler echocardiographic examinations.

The echocardiographic examinations of all the horses were performed at dissertation position, while a foot, without sedation. Using the 4th and 5th intercostal space on the left and right sides of the chest cage and by obtaining a parasternal long and short axis, the evaluations were done through the M-mode with 3, 4, 5 chamber imaging, 2-D imaging, color, and PW Doppler techniques.

M-mode echocardiographic assessments were done at the lower part of the mitral valve under the guidance of a 2-D imaging system. The right and left ventricle mass and space measurements for the end of the diastole and the end of systole were realized through the M-mode assessment values. The measurements related to the termination of systole were realized only after interventricular septum (IVS) reached its maximum thickness. Left ventricular internal diameter (LVID), left ventricular free wall (LVFW) thickness, and IVS measurements were obtained by imaging of the left ventricle taken from the right parasternal gap with the guidance of 2-D. The M-mode cursor was inserted at the lower mitral valve so that it would be in a vertical position to IVS and in a position dividing the ventricle into two parts [9,10]. The thickness of IVS, the contractibility of the left ventricle (LV), LVID, LVFW, left atrium internal diameter (LAID), aortic internal diameter (AOID) and fractional shortening (FS) were assessed by means of M-mode.

While the tricuspidal valves were evaluated for the right parasternal long axis through 2-D imaging, the mitral valves were evaluated for the left parasternal long axis imagings. The view of the long axis aorta imaging was obtained by the right parasternal long axis with 2-D imaging [11]. The AOID was measured at the end of the systole by taking the sino-tubular junction point into account [12].

The hemodynamics of the blood flow through the level of the valve was assessed both qualitatively and quantitatively by means of color and PW Doppler. The sample volume for the PW Doppler echocardiography was obtained by placing it to the back of AV valves into the atrium. Regurgitant jet are evaluated by proportioning them with the atrial volume through color Doppler echocardiography: a very small flow (less than 10% of the atrium space), a small jet flow (between 10-30% of the atrium space), a mild jet flow (between 30-50% of the atrium space), and a large jet flow (more than 50% of the atrium space) [13]. The small jet flow that were not in accordance with the clinical findings such as exercise intolerance, noisy heart sounds during the auscultation at the end of the exercise were regarded as physiological. With the observation of turbulent regurgitant flow seen as bands during the systole at both sides of the baseline, the presence of the regurgitation jet flow was determined through PW Doppler. The assessment process of aortic insufficiency through color Doppler was realized through the presence of the jet flow hanging into the LV.

In order to examine the LV diastolic functions through Doppler echocardiography, the parameters related to the total mitral current, early diastolic flow (peak E velocity), and the late diastolic (atrial) flow (peak A velocity) were measured and the E/A ratio was calculated.

RESULTS

The average values and the standard deviation obtained by M-mode in 42 horses without cardiac diseases findings are presented in *Table 1*. The average values of the speed measurements obtained from the aortic, mitral and tricuspidal levels by PW Doppler and its standard deviation in 42 horses without cardiac diseases findings are presented in *Table 2*.

Table 1. *The average values (mm) and the standard deviation obtained by M-mode echocardiography.*

Tablo 1. *M mod ekokardiyografide elde edilen ortalama değerler (mm) ve standart sapma*

IVSd	IVSs	LVFWd	LVFWs	LVIDd	LVIDs	FS%	AOID	LAIDd
32.3±5	41.4±7	26.9±4	34.8±8	122.3±6	74±4	40.4±5	88.1±6	63.1±3

Table 2. *The average speed values obtained by PW Doppler (cm/sec) and standard deviation*

Tablo 2. *PW Doppler'den elde edilen ortalama hız değerleri (cm/sn) ve standart sapma*

Aort Peak Velocity	Mitral Peak E Velocity	Mitral Peak A Velocity	Tricuspid Peak E Velocity	Tricuspid Peak A Velocity
94.5±17	76.2±23	53.8±11	73.3±19	49.8±14

In 37 cases, various cardiac diseases were detected *(Table 3)*. On 7 of 37 cases, LVIDdiastole (d) was determined between 144-162 mm, LVIDsystole (s) was between 103-139 mm and LAIDd was between 141-147 mm. Dilatation of left AV was detected. Fractional shortening (FS) was detected as between 21-26% in these cases. Diagnosis of cardiomyopathy was made. At the same time, in 2 cases of these 7 cases were seen aortic insufficiencies. In 3 of them were detected mitral insufficiencies. Besides, in 2 cases of these 7 cases which were diagnosed mitral insufficiency, tricuspid insufficiency was detected. In the cases with mitral insufficiency *(Figure 1)*, 2 cases were seen with valvular degeneration *(Figure 2)*, two of them with mitral valve prolapse and one with valvular dysplasia; in the cases with tricuspid insufficiency *(Figure 3)*, one case was seen with degeneration and one with dysplasia. Besides, in 4 of these 7 cases pericardial effusion were detected.

Table 3. *Distribution of echocardiographic findings*

Tablo 3. *Ekokardiografik bulguların dağılımı*

Primary sign	Secondery sign	Tertiary sign
LAVD (n=7)	MI (n=3) MI and TI (n=2) AI (n=2) PE (n=4) Low FS% (n=7)	VDj (n=3) VDp (n=2) MVP (n=2)
LAD (n=5)	MI (n=3) TI (n=2)	VDj (n=1)
Low FS% (n=3)		
RH (n=10)	SC (n = 6)	
PE (n=7)		
Low E:A ratio (n=5)		

LAVD: Left atrioventrcular dilatation, LAD: Left atrial dilatation, RH: Regional hypokinesia, PE: Pericardial effusion, MI: Mitral insufficiency, TI: Tricuspid insufficiency, AI: Aortic insufficiency, SC: Spontaneous contrast, VDj: Valvular degeneration, VDp: Valvular dysplasia, MVP: Mitral valve prolapse, low FS%: fractional shortening (<30%), low E:A ratio (<1)

In 5 cases, LAID was detected between values of 139-144 mm. Dilatation in LA was detected. In 3 of these cases mitral, and in 2 of them tricuspidal insufficiency were detected. In the cases with mitral insufficiency, one case was seen with valvular degeneration. On the horses without any clinical findings, the small jet flows seen on the AV valves were evaluated as physiologic and were not accepted as findings of insufficiency. Exercise intolerance was seen on the cases with AV valves insufficiency and noisy heart sounds were detected on auscultation after exercise. In the 13 cases with AV valves insufficiency, small jet flow was detected in 3 of them, mild jet flow

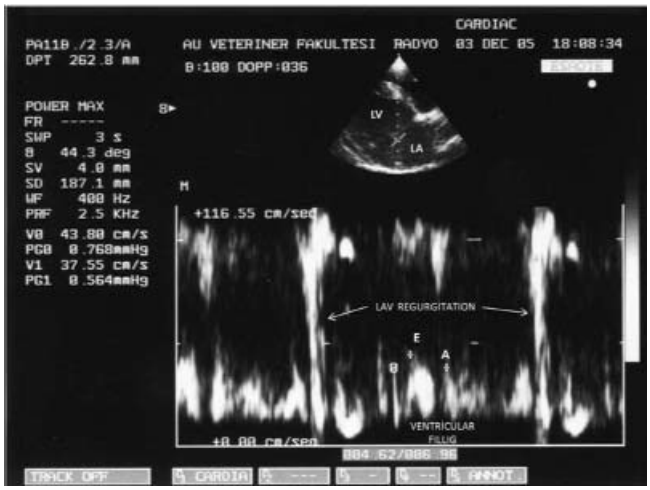

Fig 1. A PW Doppler echocardiogram obtained from the right parasternal long axis of an 11-year-old Holland horse with mitral insufficiency. The bands vertical to the baseline due to the aliasing caused by the regurgitant jet are observed as a turbulent flow

Şekil 1. Mitral yetmezliği olan 11 yaşlı Hollanda ırkı bir aygırda sağ parasternal uzun kesitten elde edilen pulsed-wave Doppler ekokardiogram. Regurgitant jet akımın aliasing oluşturması ile temel çizgiye dik olan bantlar, turbulent akım şeklinde izlenmektedir

Fig 2. An echo diagram obtained from the right parasternal long axis of a 6-year-old Holland horse with irregular thickness of the mitral valves during systole. At the same time, spontaneous contrast, which became denser at the left ventricle (LV) and right ventricle (RV), and pericardial effusion (PE) are seen as an anechoic area behind the left ventricle free wall (LVFW)

Şekil 2. Mitral kapaklarda irregüler kalınlaşma görülen 6 yaşlı Hollanda ırkı kısrağın sistol sırasında sağ parasternal uzun kesitten elde edilen ekokradiogramı. Bu ekokardiogramda aynı zamanda sol ventrikül (LV) ve sağ ventrikülde (RV) yoğunlaşan spontan kontrast ve sol ventrikül serbest duvarının (LVFW) arkasında anekoik alan olarak görülen perikardial effüzyonda (PE) izlenmektedir

Fig 3. A color Doppler echocardiogram obtained from the right parasternal long axis of a 17-year-old purebred English horse with tricuspid insufficiency. Due to aliasing, a turbulent flow may be observed with multicoloration

Şekil 3. Tricuspid yetmezliği olan 17 yaşlı safkan İngiliz ırkı aygırda sağ parasternal uzun kesitten elde edilen renkli Doppler ekokardiogram. Regurgitant jet akımın aliasing oluşturması ile karışık renklenme ile izlenen turbulent akım görülmektedir

was detected in 8 of them and a large jet flow was detected in 2 of them.

In 3 cases, FS was detected between 19-28% and no echocardiographic evidence of cardiac disease was found and a diagnosis of atrial fibrillation was made. At the same time no clinical evidence of cardiac disease was found on these 3 cases.

Regional hypokinesia was seen on LVFW in 10 cases *(Figure 4)*. Spontaneous contrast was detected on 6 of these cases. In one case with mitral valve degeneration and pericardial effusion, spontaneous contrast was accompanying to these findings. In the other 4 cases with bradycardia and Spontaneous contrast, no evidence of cardiac disease was detected on the echocardiographic evaluations. Only pericardial effusion was seen in 7 cases.

Fig 4. An echocardiogram obtained from the left parasternal long axis of a 21-year-old English horse with regional hypokinesia and spontaneous contrast. The area that did not display enough synchronisation in the left ventricle wall (LVW) during systole is shown with arrow heads

Şekil 4. Regional hipokinezia ve spontan kontrast bulunan 21 yaşlı yarım kan İngiliz beygirin sol parasternal uzun kesitten elde edilen ekokardiogramı. Sistol sırasında sol ventrikül duvarında (LVW) yeterli senkronizasyon sergileyemeyen alan ok başlıkları ile gösterilmektedir

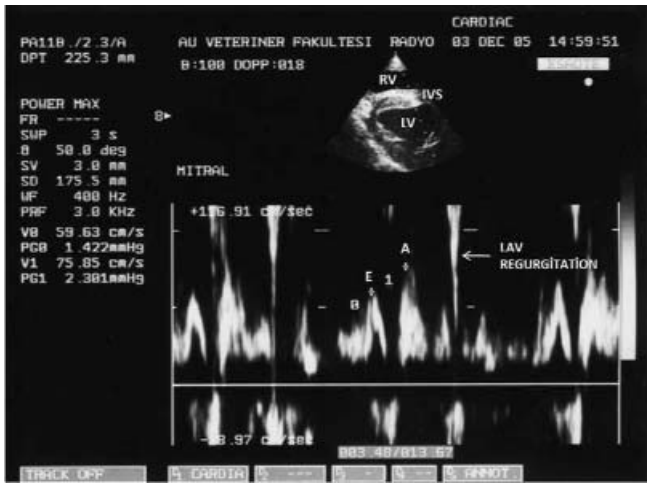

Fig 5. An echocardiogram obtained from the right parasternal long axis of a 9-year-old Sel French horse with a minimal level of mitral regurgitation together with ventricular (impaired) relaxation. The peak A velocity is observed to be much higher than the peak E velocity. The E/A ratio was 0.79

Şekil 5. Minimal derecede mitral regurgitasyon ile birlikte ventriküler (impaired) relaksiyonu olan 9 yaşlı Sel France ırkı kısrağın sağ parasternal uzun kesitten elde edilen ekokardiogramı. A dalgasının en yüksek hızı, E dalgasının en yüksek hızından daha yüksek olarak izlenmektedir. E/A oranı 0.79 olarak elde edildi

In 5 cases, E wave peak velocity obtained from the mitral valve level was smaller than the A wave peak velocity, E:A ratio was seen under 1 and a diagnosis of ventricular (impaired) relaxation was made (Figure 5). No echocardiographic evidence of hypertrophic cardiomyopathy was met in these cases.

DISCUSSION

Echocardiography is a non-invasive technique used on horses to assess the cardiological function and the morphology of the heart [10]. M-mode echocardiography has been reported to be a safe technique for investigating the structure and chambers of the heart, and the axial inner diameters, as well as being safe for the assessment of intercardiac movement [14,15]. Furthermore, the importance of this technique has been proven for the following: the measurement of the inner diameters of cardiomyopathies, and for the determination of the myocardial wall thicknesses and the computation of amplitudes [16]. Under the guidance of 2-D, M-mode echocardiographic examination in healthy horses, the LVID, thickness of the IVS, thickness of the LVFW, LAID, AOID, and left ventricle contractibility were assessed for every case in this study. Race /breed/live weight and the scope of the study have been shown to be the cause of these differences [15-18]. It has been reported that there is a correlation between myocardial thickness and live weight even though they do not vary with gender [17]. Different M-mode values occurred in these cases. It was seen that, in the sudies of Bilal and Meral [18], Bakos at al.[19], Bertone at al.[20] the values of IVS, LVID, LVFW, AOID, LAID obtained in these studies were different from each other and these values were smaller than the ones determined in our study. In the study of Young at al [21], it was seen that the values were higher than our study and in the study that Stadler at al.[17] made, the values were similar with the ones obtained in our study. It was thought that the difference might have resulted from the diversity in race.

The LV average value was during diastole 116 mm and systole 82 mm [17]. As LA enlarges, it assumes a rounded, turgid appearance and its diameter is 135 mm when measured in left parasternal long axis images [22]. Fractional shortening (FS) means decreased ventricular contraction secondary to reduced filling due to the absence of atrial component [23]. In horses with cardiomyopaties, decreased FS are usually present [24]. Horses with valvular disease, specifically, may benefit from 2-D echocardiography. Degenerative valve diseases may cause nodular or diffuse thickness in cardiac valves [25,26]. Mitral valve prolapse (MVP) is among the degenerative valve diseases [27] and it causes regurgitation [28]. MVP is a syndrome defined as the hanging out of one of two of the mitral valve leaflets into the LA space through the atrioventricular (AV) gap during left ventricular systole [29]. Dysplasia in AV valves may result in valvular insufficiency. While MVP may occur with eccentric left ventricular hypertrophy and left atrial dilatation, tricuspidal dysplasa may occur with increase in volume in the right ventricular paradoxal septal movement and right atrial dilatation [30]. A regurgital jet may be shaped at the valve level for cases of valve insufficiency. During the diastole with PW Doppler echocardiography, the blood flow hanging into the ventricular space is in a laminate form and reaches its peak level. As the regurgitant jet has a high speed, it causes aliasing and a band-shaped turbulent regurgitant flow is observed at both sides of the baseline [2]. The insufficiency in horses results in ventricular and atrial chamber enlargement or atrial dilatation without ventricular enlargement [31]. A dilation at the LV and LA was observed in 7, which were diagnosed as cardiomyopathy. In 5 cases with atrial dilatation without ventricular enlargement were detected. During studies on the degenerative valve disease cases, exercise intolerance, regurgitation, and atrial dilatation without ventricular enlargement and LAV dilatation were observed. Small jets that were not in accordance with the clinical findings were evaluated as physiological. A diagnosis of insufficiency was made when regurgitant jet at the level of the aortic, the mitral and tricuspidal valves were observed through color and PW Doppler echocardiography. The cause of the LAV dilatation might be the aortic and the mitral insufficiencies, the cause of the atrial dilatation might be the mitral insufficiancy and in some cases with AV valves insufficiency, the cause of the insufficiency was thought to be the degenerative valve disease. The coexistence of low FS, valvular insufficiencies and clinical findings related to cardiac diseases in the cases with LAV dilatation made us think that the prognosis might be poor.

Mild diseases in FS to be below 30% (normal=32-45%) have been documented in horses with atrial fibrillation, but without organic heart disease [2,23]. Consistent with the literature, in 3 cases without any evidence of heart diseases FS was seen between 19-28% in the echocardiographic evaluation. The echocardiographic diagnosis of these cases with atrial fibrillation raises the value of this technique in clinical practise.

Global and regional hypokinesia may be defined and distinguished through 2-D echocardiography. Though spontaneous contrast is often observed with myocardial dysfunction, it may not be seen as a specific finding. Spontaneous contrast cases not resulting from myocardial dysfunction may originate from bradycardia [23]. In this study, regional hypokinesia was determined at the LVFW in 10 cases and spontaneous contrast was found in 11 cases through 2-D echocardiography. The finding of spontaneous contrast in the 6 of the cases with regional hypokinesia rised a suspicion of a myocardial disease. In 1 case with mitral valve degeneration and pericardial effusion, spontaneous contrast was accompanying these findings. In the other 4 cases with bradycardia and spontaneous contrast, no evidence of cardiac disease was detected on the echocardiographic evaluations and hence it was not defined as a pathological finding.

Pericardial effusion may be determined by 2-D and M-mode echocardiography. It is also stressed that, together with the increase of the liquid between the epicardium and pericardium, a thickness in the pericardium may be observed. The causes of pericardial effusion in animals include bacterial and viral infections, trauma, neoplasia [32,33], pericardioperitoneal hernias, congestive heart failure, left atrial rupture, and benign idiopathic causes [34]. The pericardial effusion may be lead to cardiac tamponade. The right atrium is the first chamber to collapse in cardiac tamponade, but in severe cases all the chambers are affected [32,33]. Although pericardial effusion was determined for 11 of the cases, we did not observe pericardial thickness. In the 4 cases with LAV dilatation pericardial effusion was also detected at the same time. In the other 7 cases with pericardial effusion, no echocardiographic findings about neoplasia, pericardioperitoneal hernias, left atrial rupture and cardiac tamponade was found. Because of the study design's not involving the other diagnostic modalities apart from the clinical and echocardiographic examinations; the definite etiology could not be identified.

A decrease in the peak E velocity and an increase in the peak E velocity obtained at the level of the valve through PW Doppler cause a more small E/A ratio [35]. This results in an E/A ratio less than 1 [34]. This condition is called ventricular (impaired) relaxation and may be observed with hypertrophic cardiomyopathies and hypertension [36]. In our study, peak A velocity at the level of the mitral valve was observed to be higher than peak E velocity and was resulted in an E/A ratio less than 1 in 5 cases. Findings related to hypertrophic cardiomyopathy were not observed in these cases; its cause was thought to be related to hypertension.

In conclusion, echocardiographic parameters are important when clinical signs are insufficient and help equine practitioner decide definite diagnosis of cardiac diseases in addition to clinical findings. They can also useful to elucidate topography of cardiac diseases and predict their prognosis upon treatment.

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