

Echocardiographic findings in athletic horses with pulmonary regurgitation

Rostami, A.¹, Masoudifard, M.^{1*}, Vajhi, A.R.¹, Mokhber Dezfouli, M.R.², Rezakhani, A.³, Tvanaeimanesh, H.², Bahonar, A.R.⁴

¹Department of Surgery and Radiology, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran

²Department of Internal Medicine, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran

³Department of Clinical Studies, School of Veterinary Medicine, Shiraz University, Shiraz, Iran

⁴Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran

Key words:

Equine, Pulmonary valve, regurgitation, Echocardiography

Correspondence

Masoudifard, M.

Department of Surgery and Radiology, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran

Tel: +98(21) 61117079

Fax: +98(21) 66438327

Email: mmfard@ut.ac.ir

Received: 7 October 2014

Accepted: 15 December 2014

Abstract:

BACKGROUND: Determining the clinical significance of cardiac murmurs is widely considered in equine practice. Pulmonary murmurs are commonly detected in athletic horses. Echocardiography plays a leading role in assessment of these murmurs. **OBJECTIVES:** Echocardiographic evaluation of horses with pulmonary regurgitation and determining the importance of pulmonary valve murmurs. **METHODS:** A total number of 450 athletic horses were examined with focus on cardiac and respiratory systems and 18 horses (8 horses with pulmonary murmur grades 3 and 4 and 10 normal horses) were included in echocardiographic examination. **RESULTS:** B-mode, M-mode, color flow Doppler and spectral Doppler were performed on two groups and the calculated indices were compared. No statistical difference was found between the values of the two groups ($p < 0.05$). **CONCLUSIONS:** No significant correlation was found between severity of murmurs grade and the severity of regurgitating jets. We found that with moderate grades of pulmonary regurgitation, no change in cardiac indices is present.

Introduction

It is becoming increasingly difficult to ignore the importance of cardiac murmurs in athletic horses (Young and Wood, 2000; Lightfoot, Jose-Cunilleras et al., 2006; Young, Rogers et al., 2008). Because of their high prevalence, cardiac murmurs, both functional and pathologic, should be assessed carefully in order to reveal their clinical significance (Reef, 1995; Blissitt and Patteson, 1996; Kriz, Hodgson et al., 2000). These abnormal audible vibrations (i.e. murmurs) in cardiac cycle often develop as a result of valvular dysfunction (Marr Celia,

M. 2010), which causes impaired blood flow through cardiac chambers and large arteries. The athletic performance of the horses may be spoiled by the frequently occurring valvular regurgitations (Reef, 1995; Zucca, Ferrucci et al., 2010). Pulmonary regurgitation (PR) is a common echocardiographic finding in horses (Marr Celia, M. 2010), which is rarely a primary valvular disease (Reef, 1995). If the condition develops to congestive heart failure, there is a poor prognosis for longevity. Primary PR also has a poor prognosis if associated with a flail pulmonary valve leaflet, since it causes moderate to severe regurgitation (Reef, 1995).

Echocardiography is a safe and non-invasive modality which has added new perspectives to equine cardiac examination during the past three decades (Young, 1999; Rezakhani and Blissitt, 2003; Imhasly, Tschudi et al., 2010). It is possible to detect the source and clinical significance of murmurs by echocardiography. Several researchers performed different series of experiments in the past years to investigate the cardiac abnormalities in athletic horses. Most of research and clinical works so far have tended to focus on problems of other valves rather than pulmonary valve abnormalities (Young et al., 2008; Imhasly et al., 2010; Zucca et al., 2010; Richard, Fortier et al., 2010).

This survey is conducted to determine the cardiac abnormalities detected by echocardiography in horses suffering PR and critically analyzes their relationship to cardiac murmurs.

Materials and Methods

Case selection: A total number of 450 athlete horses including (236 mares, 167 stallions, and 47 geldings) Thoroughbred, Crossbred, and Arabian breeds were examined in the equestrian clubs of Tehran, Iran. Clinical and cardiac examination was performed on all horses in their own box with no chemical restraint. The data related to age, gender, breed, weight, history of disease, and athletic performance was collected. Horses with cardiac murmur were selected for further examination. All these horses were controlled clinically during the 6-month period of the study course, and they had no cardiovascular or respiratory problems. In cardiac auscultation, two independent clinicians, expert in cardiac auscultation, carefully examined both left and right hemi thoraxes. In addition, the abnormal heart sounds were recorded by an electronic stethoscope (Littmann, 4000). Intensity of cardiac murmurs was graded by the method originally described by Levine and Harvey and adapted by Patteson and Cripps (Patteson and Cripps, 1993). Hors-

es with cardiac murmurs grade 3 and 4 and the point of maximum intensity (PMI) over pulmonary valve were selected. Abnormal heart sounds originating from the pulmonary valve during diastole, audible cranial, and ventral to the aortic valve area with the stethoscope pushed cranial beneath the triceps mass were considered as PR, and 8 horses with the so-called murmurs were included in echocardiographic examination (group A). Cardiac murmurs grade 1 and 2 that usually have limited radiation were considered clinically insignificant and horses with cardiac murmurs grade 5 and 6 had no more athletic performance to be included in the current study.

A total of 10 normal horses (group B) with no clinical sign of cardiac or respiratory problems were found in the same clubs of the group A horses; they had the most similarities in weight, sex, breed, and athletic discipline with group A horses. These horses were examined like group A horses, and all the data was recorded for comparing the two mentioned groups.

Echocardiographic procedures: A systematic echocardiographic examination was performed by the same person on selected horses, and data was recorded. An ultrasound machine (Sonosite MicroMaxx (SonoSite Inc, USA) and a 1-5 MHz phase array transducer, with a maximal depth of 30cm, were used. Echocardiographic examination included B-mode, M-mode, color flow Doppler (CFD), and spectral Doppler modalities.

A semi-quantitative method of classification was used for valvular regurgitation assessment. Mild regurgitation was defined by presence of small and short jets occupying less than one third of right ventricular outflow tract (RVOT) in long axis right parasternal view of RVOT with reverse diastolic flow in pulmonary artery. Moderate regurgitation was defined as jets occupying more than one third and less than two third of RVOT. Regurgitations more than two third of RVOT were considered as se-

vere (Imhasly et al., 2010).

The ultrasound machine had an integrated electrocardiography set, where the electrocardiogram (ECG) traces were recorded throughout the entire examination. A base-apex lead system was used for ECG, with one electrode applied in the 6th intercostal space on the left side of the thorax along with a line parallel to the level of the point of the elbow, and the other electrode was placed on the top of the right scapular spine. All of the imaging stages were recorded digitally for subsequent analysis. During the examination, the animals were at rest, calm, and physically restrained only by the halter, in a quiet and relatively dark room. No chemical sedation was used.

Statistical analysis: The measured values were presented as mean \pm standard error (SE). Results were analyzed by using SPSS version 16. Data from groups A and B were analyzed using student's t-test for comparison of quantitative B-mode, M- mode and spectral Doppler indices. For all comparisons, values of $p < 0.05$ were considered significant.

Results

In order to assess the cardiac murmurs, 12 horses with pulmonary murmur were found, three of which showed low grade (1.6 and 2.6) and limited radiation murmurs and were considered clinically innocent. Nine other cases were detected having moderate intensity (grade 3.6 and 4.6) murmurs, contributing to 2% of the total study population, 8 of which with a mean body weight of 390 ± 18 kg (ranging 320-450 kg) were included in the echocardiographic examination. Mean heart rate was 38 ± 2 beats/min. Besides, a group of 10 normal horses with a mean body weight of 375 ± 16 kg (ranging 320-460 kg) were also selected and the same examinations were performed on them in order to find the normal reference values.

B-mode echocardiographic investigation of



Figure 1. Duplex (B-mode with CFD) image from a crossbred female, polo horse suffering pulmonary murmur grade 4. This is a long axis view of right ventricular outflow tract demonstrating pulmonary valve leaflets. This echocardiogram was obtained using a 1-5 phased array transducer and maximum depth of 30 cm was applied. Abnormal backward blood flow (yellow and red colors) toward the transducer during diastole is detected as occupying 33 percent of RVOT area contributing to moderate pulmonary regurgitation. No other abnormality was detected in echocardiographic examination of this horse.



Figure 2. Duplex image from 4 years-old, crossbred, female, jumping horse suffering pulmonary murmur grade 3. This is a long axis view of right ventricular outflow tract demonstrating pulmonary valve leaflets. This echocardiogram was obtained using a 1-5 phased array transducer and maximum depth of 30 cm was applied. Abnormal backward blood flow (yellow and red colors) toward the transducer during diastole is detected as occupying nearly 69 percent of RVOT area contributing to severe pulmonary regurgitation. Flail valve leaflet is a common finding in severe PR which is not detected in this echocardiogram.

the horses with pulmonary murmurs showed no abnormal morphologic changes in cardiac chamber walls and lumens. Quantitative B-

Table1. B-mode echocardiographic measurements of groups A and B. Vd= left ventricular volume in Diastole, Vs= left ventricular volume in Systole, EPSS= E point to septum separation of mitral valve, Las= left atrium diameter in Systole, Aod= aortic diameter in Diastole, PA= pulmonary artery diameter.

B- Mode measurements	Group A (Pulmonary regurgitation) No=8	Group B (Normal) No=10
Vd (cm3)	669.80±118.75	608.98±76.04
Vs (cm3)	198.26±54.46	185.65±22.47
EPSS (cm)	1.00±0.18	1.17±0.19
Las/Aod	0.81±0.06	0.70±0.04
PA (cm)	6.13±0.60	5.68±0.27
PA/Ao	0.89±0.9	0.80±0.04

Table 2- M-mode echocardiographic indices of groups A and B. d=Diasole, s=Systole, RVID= right ventricle internal diameter, LVID=left ventricle internal diameter, LVFW= left ventricle free wall thickness, FS= fractional shortening, EF= ejection fraction.

M mode indices	Group A (Pulmonary regurgitation) No =8	Group B (Normal) No= 10
RVIDd (cm)	2.62±0.22	2.65±0.26
RVIDs (cm)	1.63±0.29	1.86±0.28
IVSd (cm)	2.52±0.18	2.73±0.23
IVSs (cm)	4.29±0.31	4.34±0.19
LVIDd (cm)	10.52±0.90	10.20±0.57
LVIDs (cm)	5.92±0.71	5.95±0.37
LVFWd (cm)	3.47±0.61	3.52±0.37
LVFWs (cm)	5.48±0.95	5.45±0.32
FS %	43.60±4.29	40.73±3.93
EF %	70.76± 4.45	67.31±4.34

mode information of the horses of both groups A and B is described in table1.

The M-mode echocardiographic indices were measured and the results are presented in Table 2.

Color flow Doppler (CFD) echocardiography confirmed PR in all horses of group A. No other valvular regurgitations were diagnosed in these horses. Three horses showed mild regurgitation and four horses showed moderate regurgitation (Figure 1). Severe regurgitation was only detected in one horse (Figure 2). None of the horses in group B showed regurgitating jets with backward flow over the cardiac

valves. To determine the correlation between severity of PR versus grades of murmurs, coefficient of Pearson was calculated as -0.05 (p value 0.90). The result indicated no statistically significant correlation. Spectral Doppler indices were measured. Table 3 provides the results obtained from pulse wave spectral Doppler.

All the measured data from two groups (PR and normal) were compared statistically with level of significance set on p<0.05, and no differences were detected between the two groups.

Discussion

There is a paucity of well-established information in literature to assess the severity of pulmonary insufficiency and clinical significance of PR in athletic horses (Reef, 1995; Zoghbi, Enriquez-Sarano et al., 2003; Boon, 2011). The aim of this study was to evaluate the relationship between pulmonary murmurs and echocardiographic findings of horses with PR.

The prevalence of 2% (9 out of 450) is reported for moderate diastolic PRs in our study. This prevalence is different from the numbers given for both rare pulmonary insufficiency and very common PR (Marr Celia, M. 2010; Boon, 2011). There are few reported cases of isolated pulmonary insufficiency in the horse (Boon, 2011). Kriz et al. (2000) performed cardiac auscultation on 846 Thoroughbred racehorses and reported the prevalence of 15.9% for moderate grade (3.6 and 4.6) diastolic pulmonary murmurs and 18.1% for systolic pulmonary murmurs of moderate intensity in racehorses (Kriz et al., 2000). However, they just performed echocardiography on 2 cases of pulmonary murmurs and confirmed the presence of PR. These results differ from Zucca et al. (2010) study on estimate of pulmonary insufficiency; they investigated cardiac murmurs among 752 Standardbred racehorses and

Table 3. Spectral Doppler Echocardiographic indices of groups A and B. Ao=aortic, Pul=pulmonary, LV=left ventricle RV= right ventricle, Vmax= maximum velocity, Vmean= mean velocity, VTI= velocity time integral, ET= ejection time PEP= pre- ejection period.

Spectral Doppler indices	Group A (Pulmonary regurgitation) No=8	Group B (Normal) No=10
Ao Vmax (cm/s)	127.86±9.97	123.03±8.76
Ao Vmean (cm/s)	69.79± 6.43	66.25±5.30
Ao VTI (cm)	42.2±2.64	44.88±4.89
Pul Vmax (cm/s)	114.58±12.66	102.23±11.90
pul Vmean (cm/s)	67.60±6.52	61.35±7.01
Pul VTI (cm)	44.31± 6.63	38.1±5.26
LV ET (s)	0.47±0.04	0.58±0.04
RVET (s)	0.6±0.03	0.6±0.03
LV PEP (s)	0.09±0.01	0.11±0.01
RV PEP (s)	0.18±0.09	0.08±0.01

reported a prevalence of 0.4% for PR (Zucca et al., 2010). The authors performed echocardiographic examination on 3 cases of PR. None of the above-mentioned studies considered all horses with pulmonary murmurs in echocardiographic examination.

Right ventricular dilation is an abnormality which was postulated by Zoghbi et al. (2003) for assessment of severity of PR in Man (Zoghbi et al., 2003). It was expected to see a normal or dilated right ventricle in moderate PR and a dilated right ventricle in severe cases of PR (Zoghbi et al., 2003; Boon, 2011). The current study found that no change in cardiac chamber size is present in horses with PR. Comparison of RVID in diastole and systole in both groups of the study indicated no significant difference between the two groups.

It is stated in literature that PR is not usually associated with audible murmurs (Kriz et al., 2000; Marr Celia, M. 2010). Occasionally, loud and coarse murmurs can also be heard over pulmonary valve (Reef, 1995). This concept can be explained by the results of our study, demonstrating the presence of different grades of PR accompanied by mild to moderate audible pulmonary murmurs. However, no

tight correlation was found between severity of murmurs' grade and the severity of regurgitating jets in our study.

It is interesting to note that in one case of our study a severe PR was detected in CFD which was associated with a moderate (grade 3.6) diastolic murmur over pulmonary valve. It was expected that this severe regurgitation be seen with valvular dysplasia or after interventional procedures (Boon, 2011); however, none of these findings were detected in our case. On the other hand, the findings from just one severe PR case cannot be extrapolated to all patients. Hence, it seems that contrary to simple and available technical aspects for the expert echocardiographer, the correlation of jet size with the severity of PR is poor (Zoghbi et al., 2003).

The B-mode, M-mode, and spectral Doppler findings of the present study did not detect any evidence of controversy with previous studies.

An implication of the findings of this study is that there is no difference in echocardiographic indices between horses suffering PR of any grades and normal horses. Therefore, it can be concluded that in presence of mild and moderate PR, if no other cardiac abnormality is detected, no change in other echocardiographic indices is detectable. However, these horses should be followed up for valvular disease, because of the possibility of valve dysfunction and poor prognosis of this condition.

Acknowledgements

The authors thank the owners of the race-horses included in this study for their constructive collaborations. The authors also thank Dr. Esmaeilzadeh R., Dr. Pirzadeh H., and Dr. Tor-ki E. for their support and providing arrangements for the clinical and echocardiographic examinations.

References

1. Blissitt, K., Patteson, M. (1996) Evaluation of cardiac murmurs in horses. 2. Echocardiography. In Pract. 18: 416-426.
2. Boon, J.A. (2011) Veterinary Echocardiography. Wiley- Blackwell, Ames, Iowa, USA.
3. Imhasly, A., Tschudi, P.R., Lombard, C.W., Gerber, V. (2010) Clinical and echocardiographic features of mild mitral valve regurgitation in 108 horses. Vet J. 183: 166-171.
4. Kriz, N.G., Hodgson, D.R., Rose, R.J. (2000) prevalence and clinical importance of heart murmurs in racehorses. JAVMA. 216: 1441-1445.
5. Lightfoot, G., Jose-Cunilleras, E., Rogers, K., Newton, J.R., Young, L.E. (2006) An echocardiographic and auscultation study of right heart responses to training in young national hunt thoroughbred horses. Equine Vet J Suppl. 36: 153-158.
6. Marr Celia, M., Bowen, M. (2010) Cardiology of the Horse, Saunders Elsevier. London, UK.
7. Patteson, M.W., Cripps, P.J. (1993) A survey of cardiac auscultatory findings in horses. Equine Vet J. 25: 409-415.
8. Reef, V.B. (1995) Heart murmurs in horses: determining their significance with echocardiography. Equine Vet J Suppl. 19: 71-80.
9. Rezakhani, A., Blissitt, K.J. (2003) The role of echocardiography in the diagnosis of heart diseases in the horse. Iran J Vet Res. 4: 114-122.
10. Richard, E.A., Fortier, G.D., Pitel, P.H., Dupuis, M.C., Valette, J.P., Art, T., Denoix, J.M., Lekeux, P.M., Erck, E.V. (2010) Sub-clinical diseases affecting performance in standardbred trotters: diagnostic methods and predictive parameters. Vet J. 184: 282-289.
11. Young, L.E. (1999) Cardiac responses to training in 2-year-old thoroughbreds: an echocardiographic study. Equine Vet J Suppl. 30: 195-198.
12. Young, L.E., Rogers, K., Wood, J.L.N. (2008) Heart murmurs and valvular regurgitation in thoroughbred racehorses: epidemiology and associations with athletic performance. J Vet Intern Med. 22: 418-426.
13. Young, L.E., Wood, J.L.N. (2000) Effect of age and training on murmurs of atrioventricular valvular regurgitation in young thoroughbreds. Equine Vet J. 32: 195-199.
14. Zoghbi, W.A., Enriquez-Sarano, M., Foster, E., Grayburn, P.A., Nihoyannopoulos, P., Otto, C.M., Quinones, M.A., Rakowski, H., Stewart, W.J., Waggoner, A. (2003) Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and doppler echocardiography. J Am Soc Echocardiogr. 16: 777-802.
15. Zucca, E., Ferrucci, F., Stancari, G., Saporiti, T., Ferro, E. (2010) The prevalence of cardiac murmurs among standardbred racehorses presented with poor performance. J Vet Med Science. 72: 781-785.