Echocardiographic Evaluation of Mitral Annulus Excursion in Normal Horses

Carlos Lightowler, DVM[a]
Giuseppe Piccione, DVM[b]
Maria Laura Cattaneo, DSS[c]
Elisabetta Giudice, DVM, PhD[d]

[a]*Departamento de Medicina*
[c]*Departamento de Medicina Preventiva y Salud Publica*
Facultad de Ciencias Veterinarias
Universidad de Buenos Aires, Argentina

[b]*Dipartimento di Morfologia, Biochimica, Fisiologia e Produzioni Animali*
[d]*Dipartimento di Scienze Mediche Veterinarie*
Facoltà di Medicina Veterinaria
Università degli Studi di Messina, Italy

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ABSTRACT

Echocardiographic evaluation of systolic function is important for determination of the hemodynamic state in different cardiomyopathies to provide information for an informed prognosis and proper treatment. During each systole, the heart produces a displacement of the mitral annulus that is quantitatively related to the intensity of the ventricular contraction. This displacement, measured in two-dimensional guided M-mode, constitutes mitral annulus excursion (MAE). This value is a reliable index of left ventricular systolic function. The normal value of the MAE was determined in 30 cardiologically healthy horses. Measurements were made of the displacement of the mitral annulus in the parietal (MAEp) and septal (MAEs) portions, and their indices were calculated as a function of body weight. Statistical correlation was determined for MAEs and MAEp versus body weight. Differences between mean MAEp and MAEs also were compared.

INTRODUCTION

Among the factors that affect left ventricular systolic function, contractility plays an important role and depends largely on the function of the myocites, which form the three layers of the equine ventriculum. Several indices are used to assess systolic function, although fractional shortening is the most common in horses. Fractional shortening is easily measured and it is an indicator of the ventricular myocardium contractile state, especially in relation to the behavior of its short axis. Recent studies have demonstrated the importance of the longitudinal fibers in global myocardial contractility, especially in patients with cardiac diseases having alterations in the ventricular geometry and the contractility pattern.[1,2] In humans, the utility of measuring mitral annulus excursion (MAE) for evaluation of ventricular systolic function is recognized.[1–5] Furthermore, MAE has been

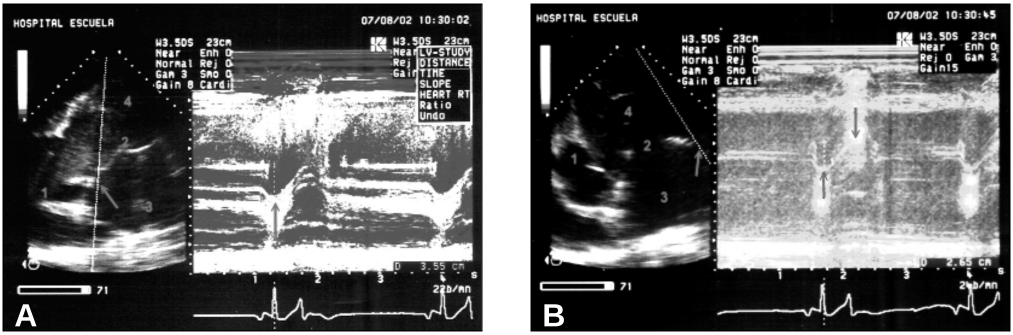

Figure 1. Panel **A** shows cursor position for evaluation of the mitral annulus excursion, septal portion. The *arrow* designates the mitral annulus, septal portion. Also shown is the aorta (*1*), septal leaflet of mitral valve (*2*), left atrium (*3*), left ventricle (*4*). Panel **B** depicats aorta (*1*), parietal leaflet of mitral valve (*2*), left atrium (*3*), left ventricle (*4*), Mitral annulus, parietal portion (*arrow*).

measured by M-mode echocardiography in normal dogs and in dogs with cardiac disease to evaluate systolic left ventricular long axis performance.[6] However, this index has never been used for routine evaluations or as measure of systolic dysfunction in horses.

The purpose of this study was to establish the echocardiographic technique for evaluation of equine MAE, to define its normal reference values for septal and parietal portions, and to establish the index value of MAE relative to body weight. Mean values for MAE in their two portions were compared and the correlation between the values of both excursions and body weight was determined.

MATERIALS AND METHODS

Subjects

Thirty horses were used in the study, with both sexes and various ages and body weights represented. All horses were cardiologically healthy as determined by clinical evaluation, a six-lead electrocardiogram, and a two-dimensional echocardiogram.

Before each evaluation, the subjects were individually weighed, and body weights were recorded within an error factor of 1 kg. All echocardiographic measurements were made from the left parasternal window without the use of chemical restraint.

Measurements

Echocardiographic evaluations were performed with a Sigma Iris 440 (Kontron) configured with 3.5-MHz mechanical sectorial transducers and a Caris model ultrasound instrument (Esaote), configured with a multifrequency electronic transducer. The excursions of the septal and parietal portions of the mitral annulus were determined and the MAE index (MAEI) as a function of body weight (BW) was calculated using the formula MAEI = MAE/BW (kg). Two-dimensional guided M-mode images were obtained using a five-chamber apical view.

For evaluation of the MAE in the septal portion (MAEs), the cursor was located where the septal valve of the mitral valve unites with the aortic ring. Measurement of the parietal portion (MAEp) movement was accomplished by placing the cursor where the parietal valve of the mitral valve articulates with the left ventricular free wall (Figure 1).

MAE layout measurements followed the principles of the American Association of Echocardiography, starting from the more proximal line of the descending wave corresponding to the atrial systole to the more proximal line of the upward motion corresponding to the ventricular systole (Figure 2).

Statistical Analysis

Linear correlation of values was determined

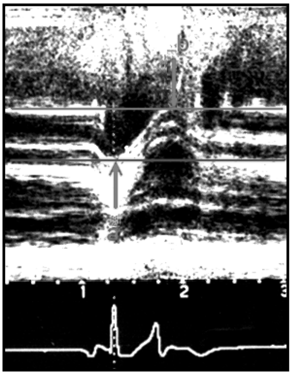

Figure 2. The mitral annulus movement is biphasic. First phase is descending (*arrow a*) and is due to atrial contraction (telediastolic or presistolic phase). Its beginning coincides with the end of the P-wave. During the isovolumetric contraction phase, the ascending trace starts and reaches its peak during ventricular systole (*arrow b*). In diastole, annulus returns to heart base producing a descending trace. The measurement of mitral annulus excursion is taken from the more proximal descending line (corresponding to atrial systole) to the more proximal line of the ascending peak (corresponding to the ventricular systole). The value is between both parallel lines.

Table 1. Mitral Annulus Excursion Index (MAEI)* Calculations for 30 Cardiologically Normal Horses

Variable	MAEI Septal	MAEI Parietal
Mean ± SD (mm/kg)	0.00816 ± 0.00116	0.00838 ± 0.00097
Range (mm/kg)	0.049–0.0102	0.0070–0.0104
Median (mm/kg)	0.00849	0.00802
1^{ST} quartile (mm/kg)	0.0737	0.00767
3^{RD} quartile (mm/kg)	0.00888	0.00923
Coefficient of variation	14.24%	11.62%

*MAEI = MAE/body weight (kg)

using Pearson's coefficient and simple linear regression, with estimators of square minima and comparison of means for matched samples. In both cases, Student's *t*-test distribution determined variables correlated well with body weight. Therefore, parameters corresponding to the descriptive statistic were applied only to MAEI values.

RESULTS

MAEp and body weight were significantly and positively correlated ($r_p = 0.6387$; $P = .0002$). Furthermore, MAEs and body weight showed a significant positive correlation ($r_p = 0.6900$; $P < .00001$). A significant positive linear regression was found for MAEs and body weight (MAEs = 0.458 + 0.007 weight; $P < .00001$; $R^2 = 0.4761$) (Figure 3) and MAEp and body weight (MAEp = 0.906 + 0.006 weight; $P = .0002$; $R^2 = 0.4079$) (Figure 3). The mean of the difference between MAEp and MAEs was not significant ($P = .84$).

MAEIs mean was 0.00816 mm/kg and the parietal portion index (MAEIp) mean was 0.00838 mm/kg. Additional variables for MAEIs and MAEIp are listed in Table 1. Linear correlations between body weight and MAEIs was $R^2 = 0.006348$ (Figure 3) and MAEIp and body weight was $R^2 =$ 3 .09685 (Figure 6).

DISCUSSION

The term mitral annulus refers to the elliptical region of the mitral valve when it is inserted at the base of the left atrium. This fibrous condensation has a three-dimensional shape of a saddle, with the basal points located medially and laterally and the apical points anterior and posterior. During the systole, the left ventricle cavity diminishes its short axis (circumferential contraction) and shortens its longitudinal axis (longitudinal subepicardic and subendocardic fibers), making the mitral annulus move toward the cardiac apex. The apex stays relatively immobile during the heart cycle.[1] The movement of mitral annulus comprises two phases.[2] The first phase is descending and is a consequence of the atrial contraction (presystolic or telediastolic phase). Its beginning coincides with the end of the P-wave on an electrocardiogram. The draw of the ascending line begins during the isovolumetric contraction period and reaches its peak during the ventricular systole. During the diastole, the annulus returns toward the base of the heart and there is a descending line. In

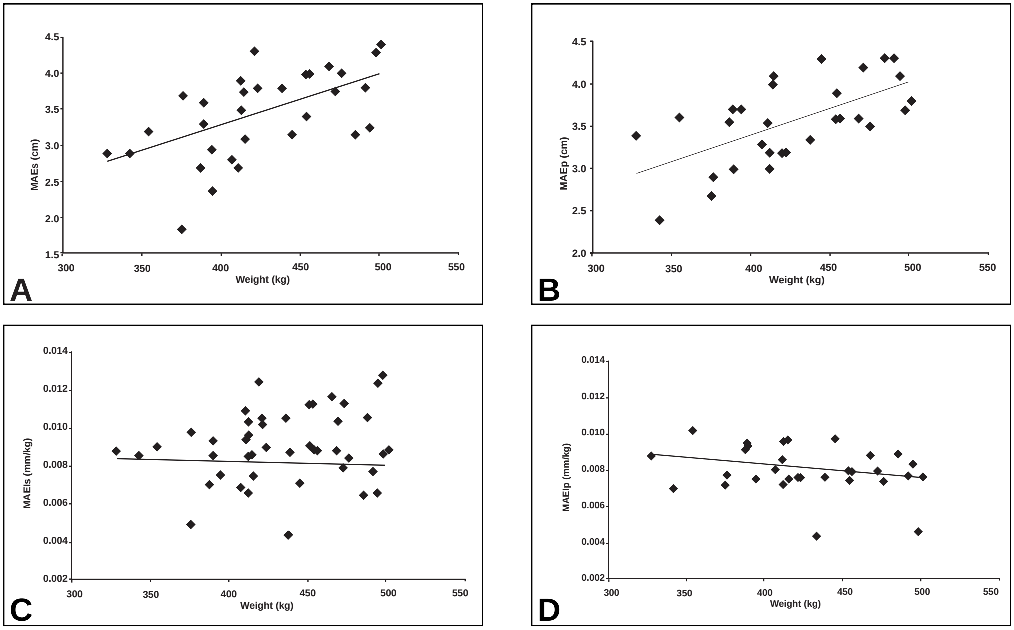

Figure 3. Scatter plot for mitral annulus excursion septal (MAEs) (**A**), MAE parietal (MAEp) (**B**), MAE index septal (MAEIs) (**C**), and MAEI parietal (MAEIp) (**D**) versus body weight in 30 clinically normal horses.

normal left ventricles, the MAE toward the apex precedes the circumferential shortening. This causes the ventricle to take on a more spherical shape early in systole.

Several investigators have used the MAE and the reduction of the long axis of the heart as indicators of the systolic ventricular function in humans.[1–5] It is known that the main excursion of the mitral annulus toward the apex in systole coincides with the systolic component of the pulmonary venous flow. Since the heart systole produces a "descent" (ascent on the instrument screen) of the atrioventricular plane, it is reasonable to assume that this displacement is an expression of the systolic function of the left ventricle in its longitudinal axis. Some important elements exist when the systolic excursion of the mitral annulus is explored. Since the movement of the mitral annulus is vertical, the two-dimensional image from which the section is obtained to form the M-mode image should have adequate direction so that the cursors can be positioned at the exact point of the maximum vertical movement. Ideally, the aortic wall and the left ventricular free wall should be as parallel as possible to the cursor. This will ensure that the intersection will move upward in its maximal amplitude (Figure 4).

There is a lack of information on MAE as an index of systolic function, and normal reference values in the horse have not been determined. It is interesting to highlight that, contrary to differing features for MAEs and MAEp in dogs, the behavior of the two portions of the mitral annulus in horses are similar. Furthermore, although significant differences do not exist in the movement of the two portions of the mitral annulus, less disparity of the values exists when they are measured on the septal portion. This could be due to the relative simplicity for obtaining the plane of this image. Until there has been opportunity to gain more experience with equine systolic function, measurements on the septal portion of the mitral annulus are recommended. For calculation of MAEI, body weight has been determined to be more practical than body surface area

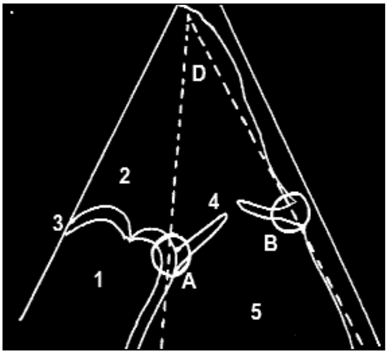

Figure 4. This drawing shows the most adequate form to obtain the point of interest to evaluate the MAE. The cursor (*D*) should be placed as parallel to the aortic wall as possible to measure the septal portion of the mitral annulus and parallel to the left ventricular free wall for the parietal portion. Landmarks designated are the aorta artery (*1*), left ventricle (*2*), aortic valve (*3*), mitral valve (*4*), left atrium (*5*), intersection for the septal portion of the mitral annulus (*A*), intersection point for the parietal portion of the mitral annulus (*B*).

because there does not appear to be a formula that is universally accepted for the calculation of the body surface area in horses.

Based on the outlined objectives and the results obtained in this study, it was concluded that the five-chamber apical view obtained from the left parasternal window is the most appropriate to measure both the septal and parietal portions of MAE. It is important to achieve a right alignment with the interventricular septum and the left ventricular free wall when both portions are measured. In this study, the correlation between MAEp and MAEs with body weight was significant, and there were no significant differences between the values of the excursion of two portions of the mitral annulus. However, because the regression of MAEs demonstrated less variability than MAEp, it is advisable to perform measurements on this portion.

In conclusion, given the lack of data about MAE and MAEI in horses, results of this study represent a starting point for defining normal values for MAEs, MAEp, MAEIs, and MAEp in normal horses.

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REFERENCES

1. Pai RG, Bodenheimer MM, Pai SM, Koss JH, Adamick RD: Usefulness of systolic excursion of the mitral annulus index of left ventricular systolic function. *Am J Cardiol* 1991; 67(2):222–224.
2. Zaky A, Grabhorn L, Feigenbaun H: Movement of the mitral ring: a study in ultrasoundcardiography. *Cardiovasc Res* 1967; 1(2):121–131.
3. Jones CJ, Raposo L, Gibson DG: Functional importance of the long axis dynamics on the human left ventricle. *Br Heart J* 1990; 63:215–220.
4. Keren G, Sonnenblick EH, LeJemtel TH: Mitral anulus motion: Relation to pulmonary venous and transmitral flows in normal subjects and in patients with dilated cardiomyopathy. *Circulation* 1988; 78(3):621–629.
5. Simonson JS, Schiller NB: Descent of the base of the left ventricle: An echocardiographic index of left ventricular function. *J Am Soc Echocardiogr* 1989; 2(1):25–35.
6. Schober KF, Fuentes VL: Mitral annulus motion as determined by M-mode echocardiography in normal dogs and dogs with cardiac disease. *Vet Radiol Ultrasound* 2001; 42(1):52–61.