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Normal M-Mode Echocardiography of Mitral Valve in Adult Domestic Swine

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Abstract: A large animal model, mainly the pig, plays a key role in the study of the biological mechanisms involved in the evolution of mitral valve pathology and research on new treatment strategies. The aim of this study was to increase the knowledge about the physiological value of ultrasound data of mitral valve in adult domestic swine. The study was performed in 80 healthy adult pigs weighing from 20-150 kg. All measurements were performed with the same anesthesia management. Researchers found that E/A Mitral flow velocity index ranged from 1.32 (50 kg body weight) to 1.47 (150 kg B.W.), E/A mitral anterior leaflet movement 2.01 (50 kg B.W.) to 1.21 (150 kg B.W.), EPSS 0.43 (50 kg B.W.) to 0.98 (150 kg B.W.). Researchers concluded that due to the clear differences in the responses of organisms in the period of physical development and adults; a study aimed at obtaining adult data should be carried out on animals which have completed their physical development. In the present study, the researchers demonstrated that the results of ultrasound and autopsy of mitral valve showed good agreement within the normal values of humans and pigs weighing 70-100 kg.

Key words: Cardiac ultrasound, pig, bicuspid valve, adults, ultrasound

INTRODUCTION

Mitral valve disease is common in humans. It is a heterogeneous group of diseases which comprises: mitral prolapse, myxoid valves dystrophies (Freed *et al*., 1999), dilatation of the mitral annulus (Boltwood *et al*., 1983; Kaul *et al*., 1989), hypertrophic cardiomyopathy, ischemic heart disease, occasionally papillary muscle or chordal rupture. A large animal model, mainly the pig, plays a key role in the study of the biological mechanisms involved in the evolution of mitral valve pathology and research on new treatment strategies.

Most of the studies carried out so far used very young animals weighing <40 kg. The choice of this group of animals has the disadvantage that it seems to be more appropriate for a pediatric model while mitral valve disease is more common in middle aged or elderly people.

Experimental studies involving imitation of this pathology in adults should therefore be carried out on mature pigs.

The main aim of this study was to increase the knowledge about the physiological value of ultrasound data of mitral valve in adult domestic swine. The second goal was to perform postmortem measurements of mitral valve annulus.

MATERIALS AND METHODS

The study was performed in 80 healthy adult pigs weighing from 50-150 kg. Studied pigs were control groups of three experiments. These experiments were prolonged, so in some animals the tests were performed repeatedly therefore the researchers obtained 163 observations. The pigs were divided into groups

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differing in body weight by 10 kg. All animals received human care in compliance with the Guide for the Care and Use of Laboratory Animals as published by the National Institutes of Health (NIH publication No. 85-23, revised 1985). All the experiments were conducted in compliance with the ethical committee of the Wroclaw University of Environmental and Life Sciences guidelines for experimentation on animals.

All measurements were performed with the same anesthesia management using mixture of midazolam+medetomidine+ketamine administered intramuscularly, with food restricted for 12 h and water for 4 h before. During the test the animal lay on the left side, the front legs stretched forward slightly. The study was performed in 20-30 min after calming the animal down when cardiac function has been stabilized.

The echocardiographic measurements were made using echocardiograph Aloka 4000+ and 3.5 MHz transducer according to the American Society for Echocardiology from at least three consecutive cardiac cycles. The flow through the mitral valve was performed in the projection, in which waves were the most visible, i.e., apical four-chamber or dual chamber view. The mitral inflow was recorded in Pulsed-Wave (PW) Doppler, the sample gate was placed at the tips of the leaflets when they are wide open. The maximum velocities of both (early inflow peak -eV and atrial inflow -aV) mitral flow waves was measured. Motion of the anterior cusp of the mitral valve was recorded in the right parasternal longitudinal and transverse projection in M-mode. The point of closure of mitral leaflet (C point), the maximum early diastolic movement of anterior leaflet toward the septum (E point, C-E), mid-diastolic movement (E-F slope), the maximum late diastolic movement of anterior leaflet toward the septum due to atrium contraction (C-A point), the distance between interventricular septum and E point (E point septal separation, EPSS) The E/A ratio was automatically calculated from Doppler and M-mode recordings. The pigs were euthanized with an overdose of pentobarbital and postmortem measurement of mitral anulus was performed. From the data obtained, the researchers calculated means and standard deviation.

RESULTS AND DISCUSSION

The echocardiographic and autopsy of mitral valve measurements are summarized in Table 1 and 2. Domestic pigs serve as laboratory animals less frequently than small animals because of the relatively high cost of the experiment but the pig model in a study of the circulatory system has one undeniable advantage: it is one of the most similar to human. This was confirmed by the results of the present analysis, since the mitral valve action and size in experimental animals were the same as in adult humans in animals which had a body weight of 70-100 kg (Table 1 and 2). Structure and motion of the mitral valve can be imaged with one and two dimensional echocardiography (Pohost *et al*., 1975), cinematography, cinefluoroscopy with radiopaque marker implantation or magnetic resonance. However, it seems that ultrasound remains the method of choice because of the low cost, low invasiveness and high accuracy. Reproducibility and high quality imaging are provided by use of modern ultrasound equipment, in particular in a three-dimensional view (Grewal *et al*., 2010). One should note, however that each of the techniques used in echocardiography provides slightly different information and only a comprehensive evaluation of all the results allows one to achieve a satisfactory quality of diagnosis. It seems, therefore that in spite of the progress in knowledge one-dimensional imaging will remain an available and important element in assessing the structure and functions of the mitral valve apparatus in human medicine and veterinary medicine, especially when conducting research or making weighty therapeutic decisions such as mitral valve surgery.

Table 1: Echocardiographic measurements in pigs weighing 50-150 kg: the flow through the mitral valve was recorded in CW Doppler (eV, Av, E/A) and movement of the anterior cusp of the mitral valve was recorded in M-mode (C-E, E-F, C-A, E/A, EPSS)

Body weight/Number of animals (n)	Mitral eV (cm sec^{-1})	Mitral aV (cm sec^{-1})	Mitral flow E/A	C-E ampl. (cm)	E-F slop (cm sec^{-1})	C-A ampl. (cm)	E/A	EPSS (cm)
50-59 kg (n = 8)	0.74±0.20	0.56±0.19	1.32	1.47±0.37	11.5±2.1	0.78±0.27	2.01	0.43±0.11
60-69 kg (n = 8)	0.87±0.37	0.70±0.27	1.25	1.77±0.40	12.1±3.9	1.28±0.36	1.44	0.54±0.12
70-79 kg (n = 9)	0.72±0.40	0.60±0.36	1.22	1.90±0.33	10.8±2.5	1.32±0.32	1.48	0.56±0.27
80-89 kg (n = 12)	0.76±0.33	0.60±0.32	1.30	1.96±0.49	11.2±3.2	1.31±0.33	1.53	0.65±0.10
90-99 kg (n = 10)	0.72±0.49	0.67±0.33	1.08	2.23±0.45	11.9±3.1	1.61±0.51	1.56	0.78±0.15
100-109 kg (n = 11)	0.69±0.45	0.59±0.51	1.22	2.38±0.38	13.2±4.1	1.72±0.28	1.40	0.89±0.34
110-119 kg (n = 16)	0.69±0.38	0.51±0.28	1.42	2.47±0.44	12.3±3.9	1.71±0.28	1.50	0.8±0.330
120-129 kg (n = 9)	0.58±0.44	0.50±0.27	1.29	2.57±0.27	11.9±4.6	1.89±0.27	1.42	0.72±0.37
130-139 kg (n = 21)	0.63±0.27	0.53±0.29	1.27	2.36±0.32	13.0±3	1.79±0.29	1.36	1.12±0.26
140-150 kg (n = 6)	0.63±0.32	0.55±0.35	1.21	2.55±0.40	14.6±3.3	1.76±0.35	1.47	0.98±0.37
Adult human	0.60-1.30	0.30-1.30	1-2	1.70-3.00	7-15	>3	>1	0.40-0.80

Table 2: Autopsy measurements of mitral annulus diameter in domestic swine and human

Swine body weight	Long axis (cm)	Short axis (cm)
70-79 kg	2.85±0.9	2.8±0.5
80-89 kg	3.65±1.1	3.0±0.3
90-99 kg	3.8±0.7	3.0±0.5
100-109 kg	3.9±0.5	3.1±0.3
110-119 kg	3.95±0.6	3.5±0.6
120-129 kg	3.96±0.6	3.8±0.4
130-139 kg	4±0.3	3.9±0.4
140-160 kg	4.5±0.9	4.0±0.9
Human	3.9	3.2

CONCLUSION

Researchers concluded that due to the clear differences in the responses of organisms in the period of physical development and adults, a study aimed at obtaining adult data should be carried out on animals which have completed their physical development. In the present study, the researchers demonstrated that the results of ultrasound and autopsy of mitral valve showed good agreement with the normal values of humans and pigs weighing 70-100 kg.

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