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Original Article

Echocardiographic and electrocardiographic parameters during the normal postpartum period in toy breeds of dogs

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ABSTRACT

The aim of this study was to evaluate echocardiographic and electrocardiographic parameters during the normal canine postpartum period. Twenty clinically healthy pregnant bitches of toy breeds (11 Miniature poodles, five Yorkshire terriers, two Maltese terriers and two Bichons Frises) were evaluated on days −3, 3, 10, 17, 24, 38, 52 and 80 relative to parturition (day 0). During the first postpartum week, the width of the interventricular septum in systole, the shortening fraction and the left atrium size decreased, while the left ventricle internal diameter in systole and end systolic stress increased. There were progressive decreases in the velocity of circumferential fibre shortening, stroke volume, cardiac output, and mitral E and A wave values. Systolic blood pressure increased markedly during the first postpartum week to gradually increase thereafter. Heart rate and corrected QT interval progressively decreased, while P wave amplitude increased. QRS complex amplitude decreased in the second week after parturition and then increased during the following weeks. In conclusion, there were changes in systolic function and some structural adaptive changes in the bitch during the first 80 days postpartum. In addition, maternal heart rate and corrected QT interval decreased, while P wave and QRS amplitudes increased.

Introduction

Canine pregnancy is characterised by important adaptive changes, many of which occur in the cardiovascular system. These changes include an increase in total blood volume and cardiac output, associated with eccentric myocardial hypertrophy, and a decrease in peripheral vascular resistance (Abbott, 2010; Blanco et al., 2011). There is a decrease in the P wave amplitude, an increase in the amplitude and duration of the QRS complex, and an increase in ventricular repolarisation time (Blanco et al., 2012).

The progression of some of these adaptive changes after parturition has been studied in human beings (Zatuchni, 1951; Robson et al., 1987), cattle (Neubert and Schäfer, 1977; Zarifi et al., 2012), goats (Olsson et al., 2001) and rodents (Wong et al., 2002; Poole et al., 2014). The postpartum period is characterised by reversal of most of the structural, functional and electrophysiological cardiac changes that occurred during pregnancy. Lactation also imposes a considerable strain on the cardiovascular system, associated with a high metabolic demand (Mezzacappa et al., 2001).

In view of the structural, functional and electrical cardiac physiological adaptive changes during canine pregnancy and lactation, it is of interest to describe their normal pattern of changes after parturition so that postpartum cardiovascular abnormalities could be detected and treated early. Whilst changes in heart rate postpartum and during lactation have been reported in bitches (Olsson et al., 2003a; Abbott, 2010), other cardiac changes after parturition have not been described. The aim of the present study was to evaluate the echocardiographic and electrocardiographic changes during the normal canine postpartum period.

Materials and methods

Animals

The study included 20 clinically healthy, pedigree, small breed pregnant bitches (11 Miniature poodles, five Yorkshire terriers, two Maltese terriers and two Bichons Frises), aged 1-5 years (mean ± standard deviation, SD, 3.55 ± 0.16 years) and weighing 1.5–6.0 kg (mean ± SD 3.6 ± 0.3 kg at postpartum day 80). After ultrasonographic confirmation of pregnancy (day −3; England et al., 2003), bitches

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were evaluated on days −3, 3, 10, 17, 24, 38, 52 and 80 after parturition (Batista et al., 2013); day 0 was defined as the day of parturition. All bitches whelped healthy puppies at term. The weaning date was 60 ± 2 days after parturition. The study was approved by the Faculty Institutional Care and Animal Use Committee (approval number 42.3.14P; date of approval 26 August 2014).

Echocardiographic evaluation

Echocardiographic evaluations were carried out with the animals in a standing position using a 7–10 MHz transducer (Toshiba Nemio XG; Chetboul et al., 2005). No sedation was required. To minimise variability, three consecutive measurements of each parameter were acquired and measured by a single trained operator (Thomas et al., 1993; Gottdiener et al., 2004; Nagueh et al., 2009). In case of marked sinus arrhythmia, six measurements of heart rate (HR) were performed.

Interventricular septum thickness in diastole (IVSd, mm) and systole (IVSs, mm), left ventricle internal diameter in diastole (LVDd, mm) and systole (LVDs, mm), and left ventricular free wall thickness in diastole (LVFWd, mm) and systole (LVFWs, mm), were measured in the right parasternal short axis view in M mode (Kienle, 1998). In the right parasternal long axis view, left atrial size (LA, mm) was measured from cranial to caudal along a line parallel to the mitral annulus that bisects the atrium (Boon, 1998; Rishniw and Erb, 2000).

As a measure of systolic function, shortening fraction (SF, %) was calculated as (LVDd − LVDs)/LVDd × 100 (Kienle, 1998). Velocity of circumferential fibre shortening (Vcf, circumferences/s), end systolic stress (ESS, dynes/cm^2) and relative wall thickness index (RWT) were calculated according to Kienle (1998), Boon (1998) and Vuille and Weyman (1994). The velocity time integral (VTI) was determined from the pulsed wave aortic spectrogram at the site of the apical transducer. Stroke volume (SV) was calculated as the product of the velocity time integral (VTI) and the cross-sectional area of the aorta (Boon, 1998). Mitral E wave (E) and A wave (A) peak velocity (m/s), deceleration time (Dt) of E wave (ms) and E/A ratio (E/A) were determined by pulsed wave Doppler measurements in the apical four chamber view.

Systolic blood pressure (mm Hg) was determined with bitches in lateral recumbency. Measurements were carried out using a Doppler flow detector (DV610 Medmega; Brown et al., 2007). Each evaluation was performed under identical conditions, using the same location, after acclimatisation for 10 min, and three consecutive measurements were recorded from the same location and position.

Electrocardiographic evaluations

A 10-lead electrocardiogram (ECG) was obtained in unsedated dogs positioned in right lateral recumbency. The animals were gently restrained with the forelimbs held perpendicular with the body and slightly separated (Ferasin et al., 2010). All electrocardiographic examinations were performed between 9.00 and 11.00 am under the same environmental conditions (Olsson et al., 2003a).

Tracings were recorded from leads I–III, aVR, aVL, aVF, CV6LU, CV6LL, CV5RL and V10 at paper speeds of 25 and 50 mm/s with a gain of 10 mm/mV. Each ECG was analysed by a single trained operator. Heart rate (beats per min, bpm) and cardiac rhythm (normal sinus rhythm or sinus arrhythmia) were assessed at a paper speed of 25 mm/s. In lead II, mean electrical axis (MEA, degrees), P wave amplitude (mV) and duration (ms), PR interval (ms), QRS complex amplitude (mV) and duration (ms), QT interval (ms) and ST segment amplitude (mV) were calculated manually at a paper speed of 50 mm/s (Tilley, 1992). The mean of each parameter was calculated on the basis of the three measured beats in case of sinus rhythm or six measured beats in case of marked sinus arrhythmia (Blanco et al., 2012). The RR interval immediately preceding each complex was recorded and QT interval was corrected (QTc) using the formula QTc = QT-0.087(RR-1000) (Tattersall et al., 2006).

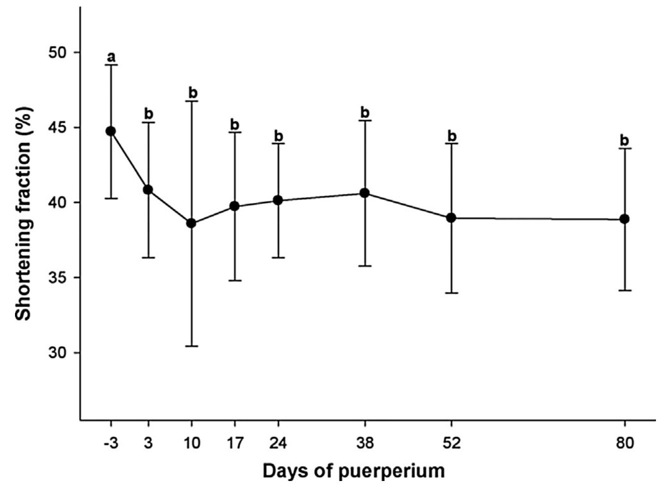

Fig. 1. Shortening fraction (SF; mean ± standard deviation). Different letters indicate significant differences ($P < 0.05$) among days.

Statistical analysis

Data were analysed using SPSS 19.0 (IBM). Normality of distribution was determined using the Shapiro–Wilk test. Variables were analysed by repeated measures analysis of variance (ANOVA), followed by Tukey's test. Cardiac rhythm was assessed using the χ^2 test. $P < 0.05$ was considered to be significant.

Results

Echocardiographic and systolic blood pressure

During the first postpartum week, IVSs ($P < 0.01$; Table 1), SF ($P < 0.01$; Fig. 1), and LA ($P < 0.01$; Table 1) decreased, while LVDs ($P < 0.01$; Table 1) and ESS ($P < 0.01$; Fig. 2) increased. Vcf ($P < 0.01$; Table 1), SV ($P < 0.01$; Fig. 3), CO ($P < 0.01$; Fig. 4), E ($P < 0.05$) and A ($P < 0.05$; Fig. 5) progressively decreased during the postpartum period. Systolic blood pressure increased most during the first week, followed by a gradual increase through the end of the study ($P < 0.01$; Fig. 6). However, IVSd, LVDd, LVFWd, LVFWs, RWT, DT and A/E remained unchanged throughout the study ($P > 0.05$; Table 1).

Electrocardiographic evaluations

Heart rate ($P < 0.01$; Fig. 7) and QTc ($P < 0.01$) progressively decreased during the postpartum period, while P wave amplitude increased ($P < 0.01$; Table 2). QRS amplitude decreased in the second week after parturition and then increased during the

Table 1
Echocardiographic parameters (mean ± standard deviation) of 20 bitches of toy breeds evaluated from day −3 to day 80 postpartum (day 0 is the day of parturition).

	Postpartum days							
	−3	3	10	17	24	38	52	80
IVSd (mm)	5.5 ± 0.5	5.6 ± 0.7	5.5 ± 0.5	5.5 ± 0.6	5.5 ± 0.7	5.5 ± 0.5	5.3 ± 0.6	5.4 ± 0.6
LVDd (mm)	21.5 ± 2	21.9 ± 1.9	22.3 ± 2.5	22.1 ± 2.1	21.9 ± 2.3	22.1 ± 2.1	21.5 ± 2.2	21.8 ± 2.1
LVFWd (mm)	4.4 ± 0.5	4.2 ± 0.5	4.3 ± 0.6	4.3 ± 0.6	4.4 ± 0.4	4.5 ± 0.4	4.6 ± 0.5	4.4 ± 0.3
IVSs (mm)	9.4 ± 0.7^{a}	8.6 ± 0.8^{b}	8.9 ± 0.9^{a,b}	8.8 ± 0.8^{a,b}	8.7 ± 0.9^{b}	9.0 ± 1.68^{a,b}	8.8 ± 1^{a,b}	8.7 ± 0.6^{a,b}
LVDs (mm)	12.0 ± 1.7^{a}	13.0 ± 1.9^{b}	13.6 ± 1.6^{b}	13.3 ± 1.8^{b}	13.1 ± 1.7^{b}	13.1 ± 1.8^{b}	13.1 ± 1.8^{b}	13.4 ± 1.8^{b}
LVFWs (mm)	6.7 ± 1	6.8 ± 0.5	6.6 ± 0.7	6.7 ± 0.8	6.5 ± 0.7	6.8 ± 0.8	6.9 ± 0.8	6.8 ± 0.9
LA (mm)	22.1 ± 1.6^{a}	20.5 ± 1.6^{b}	20.9 ± 1.5^{a,b}	20.8 ± 1.5^{a,b}	20.9 ± 1.6^{a,b}	20.9 ± 1.2^{a,b}	20.9 ± 1.5^{a,b}	20.2 ± 1.7^{b}
Vcf	3.1 ± 0.5^{a}	3.0 ± 0.5^{a,b}	2.6 ± 0.6^{b}	2.8 ± 0.7^{a,b}	2.7 ± 0.3^{b}	2.8 ± 0.4^{a,b}	2.7 ± 0.4^{b}	2.7 ± 0.5^{a,b}
RWT	0.4 ± 0.05	0.4 ± 0.04	0.4 ± 0.06	0.4 ± 0.06	0.4 ± 0.06	0.4 ± 0.05	0.4 ± 0.06	0.4 ± 0.07

IVSd, interventricular septum in diastole; IVSs, interventricular septum in systole (IVSs); LVDd, left ventricle internal diameter in diastole; LVDs, left ventricular internal diameter in systole; LVFWd, left ventricular free wall in diastole; LVFWs, left ventricular free wall in systole; LA, left atrial size; Vcf, velocity of circumferential fibre shortening; RWT, relative wall thickness. Different superscript letters indicate significant differences ($P < 0.05$) among days.