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The use of Doppler evaluation of the canine umbilical artery in prediction of delivery time and fetal distress

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ABSTRACT

The aim of this study was to describe changes in umbilical artery blood flow in the later stages of canine pregnancy. Seventeen pregnant bitches were examined sonographically to evaluate umbilical artery blood flow at the following antepartum times: 120–96, 96–72, 72–48, 48–24, 24–12, 12–6 and 6–1 h. The peak systolic velocity and end diastolic velocity were measured to calculate the resistive index (RI). Bitches were classified into two groups according to delivery method: normal delivery (Group 1, $n = 11$) and Cesarean section, due to fetal distress, (Group 2, $n = 6$). During the study, the RI of the umbilical artery in bitches in Group 1 significantly declined in the time periods 72–48, 24–12, 12–6 and 6–1 h before delivery when compared to the reference RI (120–96 h antepartum period), with values below 0.7 in the 12–6 and 6–1 h periods. In Group 2, the RI decreased significantly in the antepartum periods 96–72, 72–48, 48–24 h with respect to the period 120–96 h, and increased in the periods from 24–12, 12–6 and 6–1 h (being significantly higher in this last period) until the time of Cesarean section. Therefore monitoring of changes in umbilical artery RI in the pre-partum period may provide information about time of delivery in bitches and also assist in the diagnosis of possible dystocia and fetal distress.

1. Introduction

Conventional two-dimensional ultrasonography is a non-invasive, safe and efficient technique for monitoring fetal development and viability in veterinary medicine (England and Edward, 1990; Yeager and Concannon, 1990). However, two-dimensional ultrasonography provides little information about blood flow and therefore has been used in conjunction with Doppler ultrasound for clinical assessment in obstetrics and gynecology in a number of animal species (Nautrup, 1998; Di Salvo et al., 2006; Domingues et al., 2007; Blanco et al., 2008). Doppler ultrasound can be used to evaluate anatomical and functional vascular information such as blood flow velocity, direction and type (Nicolaides et al., 2000).

Pulsed wave Doppler allows analysis of blood flow within a single vessel. The Doppler waveform represents changes in the velocity of the blood flow during the cardiac cycle and a deflection in the late systolic or early diastolic flow is characteristic of high-resistance arterial blood flow waveforms (Blanco et al., 2008). The main flow parameters measured using this technique are the peak systolic velocity (PSV) and end diastolic velocity (EDV). The first parameter, PSV, is formed by the opening of the semilunar valves and the forward ejection of blood. This forward blood flow starts to decelerate when cardiac contraction provides insufficient forward force to overcome the elastic properties of the downstream vascular bed and

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the viscosity of blood. The EDV varies in vascular beds predominantly due to differences in downstream vascular resistance and input pressure (Gosling and King, 1975).

Another commonly measured parameter is the resistive index (RI), also known as the Pourcelot ratio, which is calculated from blood flow velocities. This index, expressed by (PSV – EDV)/PSV, indicates the downstream resistance in arteries (ranging from 0 to 1, where 0 is no resistance and 1 is maximum resistance) (Pourcelot, 1974). These parameters have also been used to assess fetal blood flow during pregnancy in a number of species (Reed et al., 1996; Bollwein et al., 2000, 2002a,b, 2003, 2004; Reynolds et al., 2006).

Fetal blood flow in the dog was first described in 1998 by Nautrup and further research has shown that Doppler ultrasonography can provide significant information on canine pregnancy (Miranda and Domingues, 2010; Blanco et al., 2011; Batista et al., 2013; Feliciano et al., 2013). Normal Doppler measurements of umbilical artery blood flow in canine fetuses have been reported (Di Salvo et al., 2006). In this species, the RI of the umbilical artery progressively decreases throughout normal gestation to ensure adequate perfusion of the placenta and fetal viscera (Nautrup, 1998; Di Salvo et al., 2006; Miranda and Domingues, 2010). However, there is no published information on the RI of the canine umbilical artery in the last days of gestation. The aim of this study was to describe and evaluate changes in umbilical artery blood flow at the end of canine pregnancy with a view to developing a method for predicting the parturition day and/or diagnosing possible dystocia and fetal distress.

2. Materials and methods

Seventeen, clinically healthy (primiparous or pluriparous), pregnant bitches of different breeds ranging from 1 to 7 years of age were included in this study. The data of the dams are shown in Table 1. All procedures were conducted in accordance with the Animal Use Committee guidelines. Two-dimensional and Doppler ultrasonographic evaluations were carried out using ultrasonographic equipment (MyLab 30 – Esaote, Genova, Italy) with a 7.5–12 MHz linear multifrequency transducer (LA523 reference – Esaote, Genova, Italy). Sonographic examinations were performed in all bitches by an echocardiographer – image acquisition was checked by one sonographer who was a member of the Brazilian College of Veterinary Radiology. The bitches were positioned in dorsal recumbency using a sponge trough, acoustic gel was applied to the transducer and abdominal hair was clipped to optimize ultrasonographic image acquisition.

The pregnant bitches were examined sonographically twice a week throughout pregnancy to determine the end of fetal organogenesis (Yeager and Concannon, 1990). After detection of fetal intestinal peristalsis (Yeager and Concannon, 1990), sonographic examination was carried out every day until delivery to evaluate blood flow in the umbilical artery. Doppler measurements were made in up to six fetuses in each pregnant bitches. When fewer than six fetuses were present, measurements were repeated in each fetus to obtain a total of six measurements in each pregnant bitch for every time period. A cross-sectional scan of the placenta zonaria was performed and the umbilical arteries in the mid-cord site of the free-floating umbilical cord were examined.

Color Doppler was used to the position of the arteries. The sample volume of pulse-wave Doppler was placed in the center of the color-coded blood flow to obtain the waveforms (Di Salvo et al., 2006). Three uniform consecutive waveforms were included and the average of the three was used. PSV and EDV were measured in m/s. Resistive index [(PSV – EDV)/PSV] was automatically calculated by the ultrasound software. The measurements were always obtained when the fetal heart rate was greater than 200 bpm.

When fetal distress was present flow measurements were acquired at the highest possible heart rate. The bitches were divided into two groups after data collection: Group 1, bitches with normal delivery; and Group 2, bitches that underwent Cesarean section due to fetal distress. Antepartum time was determined after data collection and analysis, by counting backwards from the date of delivery (where time of birth was zero hour), and divided into the following periods: 120–96, 96–72, 72–48, 48–24, 24–12, 12–6 and 6–1 h before parturition.

Table 1
Characteristics of the bitches in Groups 1 and 2, their type of delivery and numbers of fetuses.

Group	Bitch	Breed	Age	Primiparous or pluriparous	Parturition	Number of fetus
1	1	Chihuahua	2	Primiparous	Normal delivery	3
	2	Pekingese	2	Pluriparous	Normal delivery	5
	3	Maltese	2	Primiparous	Normal delivery	3
	4	Pinscher	3	Primiparous	Normal delivery	6
	5	Pug	2	Pluriparous	Normal delivery	7
	6	Schnauzer	5	Primiparous	Normal delivery	2
	7	English Cocker Spaniel	3	Primiparous	Normal delivery	6
	8	American Pit Bull Terrier	2	Primiparous	Normal delivery	6
	9	Boxer	7	Primiparous	Normal delivery	13
	10	Siberian Husky	1	Primiparous	Normal delivery	7
	11	X-breed	3	No clinical history	Normal delivery	11
2	12	Yorkshire Terrier	7	Primiparous	Cesarean – fetal distress	4
	13	Pug	1	Primiparous	Cesarean – fetal distress	3
	14	Pug	3	Pluriparous	Cesarean – fetal distress	6
	15	Schnauzer	4	Pluriparous	Cesarean – fetal distress	4
	16	Schnauzer	6	Pluriparous	Cesarean – fetal distress	4
	17	American Staffordshire Terrier	3	Primiparous	Cesarean – fetal distress	3

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