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Whelping prediction using foetal heart rate variations and umbilical artery resistivity index in late gestation#

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Abstract

The present study aimed to compare foetal heart rate (FHR) variations and umbilical artery resistivity index (RI) in late gestation for whelping prediction. Six pregnant bitches with at least three foetuses were selected for the study and the FHR variations and umbilical RI were evaluated in the last three days, ie., -3d (72-48h), -2d (48-24h) and -1d (24-12h) before whelping. The mean FHR decreased and the gradient between maximum and minimum heart rate increased as whelping approached. The physiological oscillations in FHR were inconsistent in the dogs studied and only evident in a few foetuses during 72-48h before whelping and occurred in the majority of foetuses at 24-12h before whelping. The FHR variation progressively increased and the mean umbilical artery RI decreased as gestation advanced. 50 per cent of dogs showed an umbilical RI value less than 0.7 in all three foetuses during 24-12h before whelping. Even though both these parameters when used alone were not accurate enough for whelping prediction, the sonographic detection of the decrease in the umbilical artery RI and the increased FHR variations in the majority of foetus indicated the imminence of whelping.

Keywords: *Whelping prediction, FHR variations, umbilical artery RI*

Foetal heart rate (FHR) is the major and widely used parameter to evaluate foetal viability. In dogs, the normal FHR should be greater than 200 beats per minute (bpm) and a reduction

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in FHR to less than 180 bpm indicates foetal distress (Smith, 2007). Intermittent uterine contractions over a period could cause a temporary reduction in FHR, however, it should return to normal if there is no foetal distress. These oscillations of FHR could be used as a predictor for imminent parturition (Gil *et al*., 2014). The Doppler waveform depicts changes in blood flow velocity throughout the cardiac cycle and high-resistance arterial blood flow waveforms are characterised by a deflection in the late systolic or early diastolic flow (Blanco *et al*., 2008). The major blood flow parameters usually measured were the peak systolic velocity (PSV) and end-diastolic velocity (EDV). Resistivity index (RI), which is a measurement of the degree of perfusion of vessels as well as the downstream resistance is more significant because of its least error occurrence (Di Salvo *et al*., 2006). The resistivity index of the umbilical artery progressively decreased as pregnancy advanced to ensure adequate perfusion of the placenta and foetal viscera (Di Salvo *et al*., 2006; Miranda and Domingues, 2010). Increased dependability of the parameters could be expected when the FHR variations and the umbilical artery RI were interpreted together (Gianicco *et al*., 2016). The current study aimed to examine the accuracy of whelping prediction when FHR variations and umbilical artery RI in late gestation were assessed in combination.

Materials and methods

Trans-abdominal ultrasonography was conducted using a MyLab Sigma (Esaote, Genoa, Italy) ultrasound machine. Bitches were positioned in left lateral recumbency and a multi-frequency micro-convex transducer with frequencies ranging from 3-11 MHz was used. FHR and umbilical artery RI parameters were measured in at least three foetuses from each of the six pregnant bitches and analysed.

Pulsed wave Doppler echocardiography was used to determine the FHR. Heart rate was calculated by measuring the interval between two heartbeats, by the software in the machine (Fig.1). Foetuses were considered normal when heart rate was > 200 bpm and the foetal distress was defined when FHR was consistently within a range of 160 to 190 bpm (Gil *et al*., 2014). FHR oscillations were identified by the difference in heart rate of each foetus at two-minute intervals. FHR Gradient (beats) was calculated as the number of beats between the fastest and slowest recorded heart rate and the percentage variation of FHR about the maximum heart rate was calculated as FHR variation (Gianicco *et al*., 2016). FHR oscillations and umbilical RI were evaluated in the last three days, that is, -3d (72-48h) -2d (48-24h) and -1d (24-12h) before whelping. The expected date of whelping was calculated using Nyland and Mattoon's (2002) formula at the time of pregnancy diagnosis and ultrasonographic examination was started four days before the expected date of whelping.

For the doppler parameters of the umbilical artery, a cross-sectional scan of the zonary placenta was performed. The umbilical arteries in the mid-cord site of the free-floating umbilical cord were examined (Fig. 2). Colour Doppler was used for locating the position of the umbilical arteries and the pulsed-wave Doppler sample gate was placed at the centre to obtain the waveforms. Various waveforms obtained for the study were manually traced to measure the RI of three consecutive waves. The software of the ultrasound scanner's flow velocity index (FVI) mode automatically determined the RI values for each recording.

Statistical analysis was done by SPSS version 24.0 and the FHR gradient, FHR variation and umbilical artery RI in the different time intervals under study was compared by repeated measures ANOVA.

Results and discussion

All the bitches were small-sized and comprised of three beagles, two French bulldogs and a pug.

Foetal heart rate

As the pregnancy advanced, fluctuations in the foetal heart rate were noticed. From 72h to 12h before whelping, oscillations in the FHR evinced by accelerations and decelerations were recorded. Along with an oscillating course, a decreasing trend in FHR was observed as the parturition approached. On statistical analysis, a significant difference

(P< 0.05) in the FHR (bpm) was observed between the last three days before whelping. (236.43 ± 3.11 at 72-48h, 211.857 ± 3.81 at 48-24h and 193.571 ± 4.97 at 24-12h). Frasch *et al*. (2007) explained that the decrease in FHR during the second half of pregnancy was due to the maturation of vagal cardiac control.

FHR Oscillations

The oscillations of FHR were observed from 72h before the day of parturition. The minimal FHR dropped as the interval before whelping decreased and the range between the maximum and minimum readings increased during the time interval from 72h to 24h before parturition. Gil *et al*. (2014) described cycles of deceleration and subsequent acceleration in the FHR, starting 72h before parturition that was detected in all the foetuses of the litter in the 6h before the occurrence of normal parturition with a range of 119 to 242 bpm. A low FHR when associated with a subsequent increase in FHR to ≥ 200 bpm, should be considered physiological and defined foetal distress as the consistent reduction in foetal heart rate (between 160 and 190).

The mean HR gradient (beats) were 13.01 ± 1.09, 17.17 ± 2.57 and 24.83 ± 3.64 respectively during 72-48h, 48-24h and 24-12h before whelping. There was a significant difference (P<0.05) in the FHR gradient between 24-12h and the remaining period (48 and 72h before whelping) (Table 1). The physiological oscillations in FHR were not consistent in all the foetuses studied and were. They were observed in a few foetuses during 72-48h before whelping and the majority of the foetuses showed these oscillations in 24-12h before whelping. In five out of six animals, the oscillations of FHR were evident in all the foetuses during 24-12h before whelping.

Table 1. Mean (±SE) FHR gradient (beats) during the last 3d before whelping

Interval before whelping	Mean (± SE) (beats)
72-48h	13.01[a] ± 1.09
48-24h	17.17[a] ± 2.57
24-12h	24.83[b] ± 3.64

Means with different superscripts vary significantly P< 0.05

The FHR variation progressively increased during the last three days before parturition, starting at 5.31±0.47 during 72-48h, 7.95±1.25 in 48-24h, and reaching 13.01±1.68 in 24-12h before whelping (Table 2). The maximum variation observed in a single foetus was 26.24 per cent which occurred in the 24-12h period. Giannico *et al*. (2016) reported that the coefficient of variation for FHR progressively increased, starting at 6.9 per cent in the 120–96h period and reaching 14.9 per cent in the 12–1h period. The HR variation values greater than 24.48 per cent may occur within 12 h before parturition, although this same percentage of variation was observed in some foetuses 72-48 h or 24-12 h before parturition. The FHR variation values higher than 30.67 per cent occurred only in the immediate prepartum period (12- 1h).

Table 2. Mean (±SE) FHR variation (per cent) in the last 3d before whelping

Interval to whelping	FHR variation (per cent) Mean ± SE
72-48h	5.31[a] ± 0.47
48-24h	7.95[a] ± 1.25
24-12h	13.01[b] ± 1.68

Means with different superscripts vary significantly P< 0.05

FHR variations in a single foetus could not be helpful for whelping prediction, since FHR variations of more than the mean values of 24-12h before whelping were observed in a single foetus at 48h before whelping. Fifty per cent of the dogs that whelped within 24h had less than the mean FHR variation (13.01 per cent). Hence, FHR variation could not be the sole parameter for whelping prediction.

Umbilical artery RI

In the current study, the mean (±SE) of umbilical artery RI during 72-48h, 48-24h, and 24-12h before the onset of parturition were 0.71±0.01, 0.7±0.01, 0.67± 0.01. The mean RI of the umbilical artery decreased during the 12-24h period before whelping (Table 3). As the gestation advanced, the diastolic peak would appear and the progressive development of the foetal or placental circulation was responsible for the decrease in RI (Gaikwad,

2020). However, the reason for the drop in RI was not clear and it could be due to maternal/ foetal circulation or other maternal factors. The RI of the umbilical artery below 0.7 in the foetus indicated that the delivery was imminent. If the RI of all the foetuses were less than 0.7, then the normal parturition could be expected within 12 h (Gianicco *et al*., 2015).

Table 3. Mean (± SE) of umbilical artery RI during the last 3d before whelping

Interval before whelping	Mean (± SE)
72 -48h	0.71^{a} ± 0.01
48-24h	0.70^{a} ± 0.01
24-12h	0.67^{b} ± 0.01

Means with different superscripts vary significantly P< 0.05 level

In the study of Gianicco *et al*. (2015), the mean RI of umbilical arteries at 72-48h, 48-24h, and 24-12h before whelping were 0.74 ± 0.03, 0.75 ± 0.04 and 0.72 ± 0.04 respectively. The authors suggested that the RI of the umbilical artery below 0.7 in the foetus indicated that the delivery was imminent. If the RI of all the foetuses were less than 0.7, then the normal parturition could be expected within 12 h (Gianicco *et al*., 2015). In the present study, the umbilical RI of all three foetuses below 0.7 occurred only in one animal in the 48-24h period and 50 per cent of animals showed an RI value of less than 0.7 in all three foetuses in 24-12h period. Only in a French bulldog, RI did not reduce in two foetuses (0.8) during the 24-12h period and a caesarean section was done on the next day due to foetal distress. This is in accordance with Gianicco *et al*. (2015), who reported that the increased umbilical artery RI in advanced pregnancy indicated foetal distress.

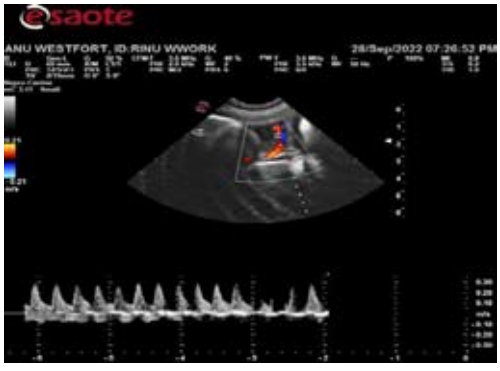

Fig. 1. Estimation of FHR using Pulse wave Doppler

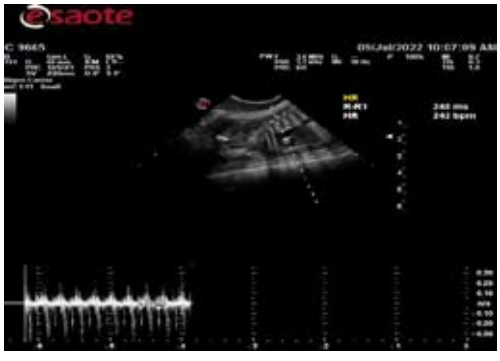

Fig. 2. Colour Doppler visualisation of the umbilical artery and its pulse wave Doppler waveform

Conclusion

FHR oscillations were observed from 72h before whelping and maximum oscillations were observed at 24h-12h before whelping. FHR oscillations in the majority of the foetuses indicated that whelping may occur within 24-12h. In 50 per cent of dogs that whelped within 24h, the average FHR variations of three foetuses increased to 13.01 per cent at 24-12h from 5.31 per cent at 72-48h before whelping. FHR variations in a single foetus could not be helpful for whelping prediction. The average RI values were not helpful and the individual values should always be considered. Sonographic detection of the decrease in the umbilical artery RI in any foetus at late gestation should alarm the clinician that the other foetuses also tend towards a decrease in RI. In contrast, an increase in RI should be considered as ensuing foetal distress. Such changes in umbilical artery RI could alarm the clinician that the whelping might be challenging and that the early foetal distress should not be ignored for favourable outcomes. It could be inferred that HR variation along with umbilical artery RI in the majority of the foetuses specified the imminence of whelping.

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