Original Article

Clinical evaluation of the accuracy of foetal radiographic findings in parturition date prediction of small size dogs

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Abstract

Ultrasonographic measurements of extra-foetal or foetal structures have been reported as an accurate means of predicting the date of parturition in the bitch. However, for many years, radiography has been clinically useful for pregnancy diagnosis, determining the number of foetuses and prolonged foetal death. Guidelines for estimating the canine parturition date based on foetal skeletal mineralization in relation to gestational age and preovulatory LH surge have been applied in small animal practice. The aims of this retrospective study were to evaluate the accuracy of parturition date prediction using foetal radiographic findings in small size dogs (1-10 kg), and to determine factors affecting the accuracy of predicting. Bitches of different breeds were submitted for pregnancy diagnosis using a computed radiography system, and images (both ventrodorsal and lateral views) were evaluated by two radiology specialists. The retrospective study involved pregnancies of 92 small size bitches showing natural onset of parturition. Prediction of parturition date was made according to the guideline previously published; days before parturition (DBP) was calculated based on pregnancy length of 65 days. Only 11.9% (11/92) whelped on the prediction date. Parturition mostly occurred before the prediction date (3.4 ± 2.5 days, range 1-11) in 64 out of 92 bitches (69.6%), and 18.5% (17/92) of bitches whelped after the predicted date (2.2 ± 1.5 days, range 1-5). The accuracy rates when predicting the delivery day within ±1 day, ±2 days and ±3 days were 36.9% (34/92), 56.5% (52/92) and 66.3% (61/92), respectively. In this study, the factor affecting the accuracy of parturition prediction was gestational age (r=0.27, P=0.008). Close to term (64-65 days of pregnancy), the accuracy of parturition prediction was significantly lower than those obtained during 48-63 days (P<0.01). Maternal age (P=0.09), body weight (P=0.4) and litter size (P=0.88) did not affect the prediction accuracy. In conclusion, the canine parturition date was predictable using radiographic identification of foetal bony structures with low accuracy. Because the minority (11.9%) whelped on the prediction date and most of pregnant bitches (69.6%) whelped before predicted parturition date, the accuracy is not acceptable to time planned caesarean section.

Keywords: Dog, Parturition date, Prediction, Radiography

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Introduction

Determination of gestational age is essential for breeding programmes. An optimal management of pregnancy monitoring and preparation for parturition allows a better planning for breeders and veterinarians to reduce losses of offspring during the peripartum period especially for bitches having a high risk for dystocia. Assessment of canine gestational time and prediction of parturition date is a challenging task in small animal practice, particularly when it comes to elective caesarean section because the operation can safely be performed only 2 days before the actual due date (Concannon, 2005). If gestational age is not calculated correctly, early planned caesarean section can add risks for the dam (severe uterine bleeding from placental sites) and puppies (low birth weight and respiratory problems). The selection of a bitch for elective caesarean section may include any of these criteria: brachycephalic breed, a previous history of dystocia, progestin-treated pregnant bitches, single pup pregnancy, large litter size of eight or more, nulliparous bitch ≥ 6 years old, owner living in an area with limited access to after-hour care (Smith, 2007). In addition, miniature and small breeds are known to have a high risk for dystocia (Münnich and Küchenmeister, 2009).

The canine gestation length is highly variable as much as 14 days (57-72 days) from the day of breeding (Concannon *et al*., 1983). This variability must be considered when evaluating the accuracy of diagnostic tests used for pregnancy and estimating parturition date. Regardless of dog breed and body size, prediction of parturition date is more accurate when timed from the preovulatory LH surge or ovulation. Because the preovulatory LH surge is estimated to occur 2 days prior to ovulation, a 65±1 day gestational length measured from LH surge to parturition is the same as a 63±1 day interval between ovulation (Concannon *et al*., 1983). Nevertheless, in some clinical circumstances, serological tests of hormone concentrations (LH or progesterone) and exfoliative vaginal cytology to time ovulation and/or the period of preovulatory LH surge in the bitches are not evaluated.

Recently, determination of gestational age and the prediction of whelping date in the dog have gained a great interest in the area of veterinary obstetrics. Methods proposed can be categorised into 4 topics: (i) determination of ovulation and hormonal assays, (ii) first appearance of embryonic/foetal structures using ultrasonographic or radiographic examination, (iii) ultrasonographic measurement of extra-foetal or foetal structures, and (iv) ultrasonographic evaluation of foetal flux or heart rate (Beccaglia *et al*., 2016). Although ultrasonography is reliably used to predict parturition date with high accuracy, radiographic evaluation of foetal skeletal structures to diagnose pregnancy and to assess the number of foetuses is commonly performed in veterinary practice. Furthermore, because the developmental changes in foetal mineralization occur at consistent times in canine foetal ontology (Rendano *et al*., 1984), determination of gestational age in relation to parturition date prediction can be estimated. Guidelines for estimating parturition date based on varying degree of foetal skeletal mineralization have been reported in the dog (Rendano *et al*., 1984; Toal *et al*., 1986) and cats (Haney *et al*., 2003). In cats, date of parturition is predictable within ±3 days in approximately 75% (Haney *et al*., 2003).

It has been stated in a case report by Root Kustritz (2002) that assessment of mineralized foetal components on a high-quality radiographic view of the abdomen allows accurate estimation of gestational age and projected date of parturition. To our knowledge, clinical evaluation of the accuracy of foetal radiographic findings in canine parturition date prediction is lacking. The purpose of the retrospective study was to evaluate the accuracy of foetal radiographic findings in predicting the canine parturition date in small size dogs (1-10 kg), and to determine factors affecting the accuracy of predicting, i.e. gestational age, maternal age, maternal body weight and litter size.

Materials and Methods

Animals: In this retrospective study, small size dogs of different breeds were submitted for pregnancy diagnosis and/or determining the number of foetuses at Small Animal Teaching Hospital, Faculty of Veterinary Science, Chulalongkorn University. Only healthy bitches showing natural onset of parturition were included. The actual dates of whelping, maternal factors including the age and body weight before pregnancies as well as litter size were recorded. The Ethical Committee for Animal Use of Faculty of Veterinary Science, Chulalongkorn University approved the research protocol (Number 1531025).

Radiographic evaluation: Dogs were gently restrained without sedation in right lateral and dorsal recumbency for imaging using a computed radiography system. Images were evaluated by 2 radiology specialists who were unaware of the time of breeding. Detectable mineralisation of all skeletal components was recorded. Gestational age and prediction of parturition date were made according to literature reviews previously published (Johnston *et al*., 2001; Lopate, 2008) (Table 1). Days before parturition (DBP) is calculated based on pregnancy length of 65 days timed from the LH surge (Table 1). This table has long been used in our teaching hospital to evaluate gestational age and suggest a whelping date. For example, when pelvis and all 13 pairs of ribs are visible in the puppies, the parturition will typically occur in 11 days (range, 7-13 days). The interval until whelping was present as DBP. Litter size was evaluated from lateral and dorso-ventral computed radiographs.

Statistical analysis: The correlation of factors affecting the accuracy in predicting whelping date was analysed using Spearman's rank correlation test. Data analyses of gestational ages and the accuracy of parturition prediction were carried out by using general linear mixed models. Least square means were obtained from each class of the factor (48-55 days, 56-59 days, 60-63 days and 64-65 days) and were compared by using least significant difference (LSD) test. A value of $P<0.05$ was considered statistically significant.

Table 1 Foetal skeletal structures used to determine the stage of canine pregnancy measured from the preovulatory LH surge. Days before parturition (DBP) are calculated based on pregnancy length of 65 days timed from the LH surge (modified from Johnston *et al*., 2001 and Lopate, 2008).

Foetal skeletal structures	Detection (day)		DBP	
	Mean	Range	Mean	Range
First evidence of mineralization of the fetal skull and spine	45	43-46	20	20-22
Scapula, humerus and femur	48	46-51	17	15-18
Radius, ulna and tibia	52	50-53	13	9-13
Pelvis and all 13 pairs of ribs	54	53-59	11	7-13
Coccygeal vertebrae, fibula, calcaneus and distal extremities	61	55-64	4	2-9
Teeth	61	58-63	4	3-8

Results

The pregnant bitches (n=92) were enrolled in this study. They were healthy according to physical examinations and blood profiles and had no clinical signs of abnormal pregnancy (abortion, vaginal bleeding or malformed foetuses). The maternal and gestational factors including age of the pregnant bitches, body weight before pregnancy, gestational age and litter size were shown in Table 2. Only 11.9% of bitches (n=92) whelped on the prediction date (Table 3). Interestingly, the majority (69.6%, 64/92) of pregnant bitches whelped before predicted parturition date (3.4 ± 2.5 days; mean ± S.D.), and the percentage of bitches that whelped 1, 2, 3 and >3 days before estimating time to parturition was 26.5% (17/64), 17.2% (11/64), 12.5% (8/64) and 43.8% (28/64), respectively. It took 2.2 ± 1.5 days for the bitches whelped after the predicted parturition date (Table 3). Date of parturition was predictable within ±1 day, ±2 days and ±3 days in 36.9% (34/92), 56.5% (52/92) and 66.3% (61/92), respectively (Table 4).

Factors that affect the accuracy of parturition prediction using foetal skeletal appearances were analysed. The gestational age positively correlated (r=0.27, P=0.008) with the accuracy of parturition prediction. Close to term (64-65 days of pregnancy), the accuracy of parturition prediction was significantly lower (P<0.01) than those obtained during 48-63 days of pregnancy (Table 5). Maternal age (P=0.09), maternal body weight (P=0.4) and litter size (P=0.88) did not affect the accuracy of parturition date prediction in small size bitches.

Table 2 The maternal and gestational factors including age, body weight before pregnancy and litter size (n=92)

Factors	Mean ± S.D.	Min	Max
Age (years)	2.8 ± 2.7	0.7	13
Body weight (Kg)	3.7 ± 1.9	1.6	10
Gestational age (days)	59.4 ± 4.5	48	65
Litter size	3.1 ± 1.5	1	10

Table 3 The number of bitches delivered before, after and on the predicted whelping date and mean ± S.D. of days when whelping occurred before and after the prediction date

Predicted whelping date	Number of bitches (n=92)	Percentage	Days	
			Mean ± S.D.	Range
Before	64	69.6	3.4 ± 2.5	1-11
After	17	18.5	2.2 ± 1.5	1-5
On the date predicted	11	11.9	-	-

Table 4 The accuracy (±1, ±2 and ±3 days) of parturition date prediction in bitches (n=92)

Accuracy within days	Cumulative frequency (dogs)	Percentage
±1	34	36.9
±2	52	56.5
±3	61	66.3

Table 5 Mean ± S.D. of the accuracy of parturition date prediction grouped by gestational ages

Gestational ages (days)	Number of dogs (n=92)	Accuracy (±days)
48-55	23	2.3 ± 0.6[a]
56-59	16	2.8 ± 0.9[a]
60-63	34	2.2 ± 0.6[a]
64-65	19	4.6 ± 0.7[b]

Different letters (a,b) within a column indicate significant differences (P<0.05) of the accuracy.

Discussion

In veterinary practice, the radiographic identification of foetal bony structures is commonly used as a reliable method of pregnancy diagnosis in the dog during the third trimester when rapid development of foetal skeletal mineralization occurs. Mineralization of a foetus was first detected at 21 days prior to parturition in dogs (Rendano *et al*., 1984) and at 25 to 29 days in cats (Haney *et al*., 2003). Around 45 days after the preovulatory LH surge, the first evidence of the foetal skull and spine are seen radiographically.

In this study, small size dogs were enrolled (n=92) because they are at higher risk of dystocia compared to medium or large breeds (Münnich and Küchenmeister, 2009). Therefore, parturition date prediction will help manage a better preparation of whelping or planned caesarean section to increase puppy survival rate. The first report of radiographic evaluation of mineralized foetuses in relation to parturition date prediction was published in 1984, and only 6 pregnant beagles (medium size dogs) were included (Rendano *et al*., 1984). To our knowledge, the present study was the first clinical observation to evaluate the accuracy of parturition date prediction using radiographic findings of foetal skeletal structures in small size dogs.

According to the suggested guideline to determine gestation age and days before parturition shown in Table 1, the majority of pregnant bitches whelped before the prediction time, and only 11.9% of bitches whelped on the prediction date. These findings indicated that prediction of parturition date using foetal radiography underestimated the gestational age resulting in whelping prior to prediction time. However, differences between small and medium breeds of dogs could also be an explanation because small size dogs were used in our study but medium size dogs were used to report the relationship between parturition date and foetal skeletal mineralization detected radiographically in a previous study (Rendano *et al*., 1984). It is known that foetal development and growth rate of the foetus differ between dog breeds (small, medium or large). Reference guidelines to determine gestation age in relation to foetal radiographic findings of small- and large size dogs warrants further investigation to determine whether the stage of foetal mineralization differs among dog breeds. In small size dogs, it is possible that mineralization of the foetus becomes radiographically apparent earlier than those seen in medium size dogs.

Prediction of parturition date using foetal radiographs provided more accurate prediction instead of breeding dates, but it is not sufficiently accurate when compared to sonographic measurement of foetal biometry. Our findings showed that the accuracy within a ±1 day and ±2 days interval was 36.9% and 56.5%, suggesting that radiographic modality is not a good diagnostic tool for accurate prediction of the parturition date. In comparison with ultrasonographic measurement of foetal biparietal diameter of small dogs, the overall accuracy for parturition date prediction calculated form the time of ovulation was 75% for the Day 63 ± 1 prediction and 88% for the Day 63 ± 2 prediction (Luvoni and Beccaglia, 2006). These suggested that the radiographic detection of foetal skeletons was not as a good indicator for accurate predicting term as sonographic foetal biometry because of the variable mineralization times of foetal bony components and some overlap of radiographic details between bitches and amongst breeds (Lopate, 2008).

In clinical practice, radiographs could be used to properly prepare for whelping, but planned caesarean section could not be accurately timed using radiographs alone because the prediction accuracy within ±1 days was very low being only 36.9% and variability of the accuracy ranged between 1 and 11 days. It is interesting to note that two third of pregnant bitches whelped before the predicted parturition date (3.4 ± 2.5). Clearly, if foetal radiographic findings are used as a single tool to time a planned caesarean section, the bitches and their puppies could be at a high risk when caesarean section is performed too early. Determination of preovulatory LH surge, day of ovulation, ultrasonographic measurement of inner chorionic cavity or fetal biparietal diameter are most accurate methods of predicting parturition date (Lopate, 2008; Luvoni and Beccaglia, 2006; Kutzler *et al*., 2003), especially, when planned caesarean section is scheduled. Nevertheless, if above methods could not be examined, monitoring a decline in near-term progesterone concentrations (De Cramer and Nöthling, 2018; Kim *et al*., 2007), pre-partum drop in rectal temperature (Luvoni and Beccaglia, 2006) and signs of impending parturition (decreased appetite, nesting, panting, lactation) (Kim *et al*., 2007) may help radiographs to more accurately time the day of parturition.

The results in this study indicated that the accuracy of parturition prediction determined by foetal bony structures was affected by the gestational period. Late gestation resulted in low accuracy of parturition prediction, particularly 2 days prior to parturition. Our findings were in agreement with a previous study using foetal biparietal diameter to calculate the parturition term (Beccaglia and Luvoni, 2012). Maternal age, body weight and litter size did not affect the accuracy of parturition date prediction in small size bitches.

In conclusion, the accuracy of parturition date prediction using radiographic identification of foetal bony structures was poor and this method solely is not acceptable to time elective caesarean section. When the parturition date was predicted using foetal radiographs, the majority of pregnant bitches whelped prior to the prediction date.

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References

Beccaglia M, Luvoni GC. 2012. Prediction of parturition in dogs and cats: accuracy at different gestational ages. Reprod Domest Anim. 47 (6): 194-6.

Beccaglia M, Alonge S, Trovo' C, Luvoni GC. 2016. Determination of gestational time and prediction of parturition in dogs and cats: an update. Reprod Domest Anim. 51(1): 12-7.

Concannon P, Whaley S, Lein D, Wissler R. 1983. Canine gestation length: variation related to time of mating and fertile life of sperm. Am J Vet Res. 44 (10): 1819-21.

Concannon PW. 2005. Understanding and monitoring canine pregnancy. In: Proceeding World Animal Vet Assoc.

De Cramer KGM, Nöthling JO. 2018. The precision of predicting the time of onset of parturition in the bitch using the level of progesterone in plasma during the preparturient period. Theriogenology. 107: 211-218.

Haney DR, Levy JK, Newell SM, Graham JP, Gorman SP. 2003. Use of fetal skeletal mineralization for prediction of parturition date in cats. J Am Vet Med Assoc. 223 (11): 1614-6.

Johnston *et al*. 2001. In: Canine and Feline Theriogenology. WB Saunders Co. 74 pp.

Kim Y, Travis AJ, Meyers-Wallen VN. 2007. Parturition prediction and timing of canine pregnancy. Theriogenology. 68 (8): 1177-82.

Kutzler MA, Mohammed HO, Lamb SV, Meyers-Wallen VN. 2003. Accuracy of canine parturition date prediction from the initial rise in preovulatory progesterone concentration. Theriogenology. 60 (6): 1187-96.

Lopate C. 2008. Estimation of gestational age and assessment of canine fetal maturation using radiology and ultrasonography: a review. Theriogenology. 70 (3): 397-402.

Luvoni GC, Beccaglia M. 2006. The prediction of parturition date in canine pregnancy. Reprod Domest Anim. 41 (1): 27-32.

Münnich A, Küchenmeister U. 2009. Dystocia in numbers - evidence-based parameters for intervention in the dog: causes for dystocia and treatment recommendations. Reprod Domest Anim. 44 (2): 141-7.

Rendano VT, Lein DH, Concannon PW. 1984. Radiographic evaluation of prenatal development in the Beagle: correlation with time of breeding, LH release and parturition. Vet Radiol. 132-41.

Root Kustritz MV. 2002. Theriogenology question of the month. JAVMA 220 (6): 747-8.

Smith FO. 2007. Challenges in small animal parturition--timing elective and emergency cesarian sections. Theriogenology. 68 (3): 348-53.

Toal RL, Walker MA, Henry GA. 1986. A comparison of real-time ultrasound, palpation and radiography in pregnancy detection and litter size determination in the bitch. Vet Radiol. 27: 102-8.