

Accuracy of canine parturition date prediction using fetal measurements obtained by ultrasonography

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Abstract

The length of canine gestation is 65 days from the luteinizing hormone (LH) surge. Early and accurate determination of canine gestational age is useful for predicting and managing parturition. We performed a retrospective study on fetal measurements obtained by transabdominal ultrasonographic examination of 83 bitches (32 breeds) to estimate gestational age. Gestational age was estimated using two published tables correlating either (1) embryonic vesicle diameter (EVD), crown-rump length (CRL), body diameter (BD), and biparietal diameter (HD) to the LH surge in mid-gestational beagles or (2) BD and HD to parturition in late-gestation retrievers. Parturition date was predicted by obtaining the difference between the gestational age estimate and 65 days. Bitches were divided into four body weight (BW) groups based on nonpregnant body weight: small (≤ 9 kg), medium (>9 – 20 kg), large (>20 – 40 kg), and giant (>40 kg). Mean $\pm$ S.D. litter size (LS) was calculated for each BW group. The BW groups were then divided into small, average, or large LS groups. The accuracy of the prediction was not affected by LS but was affected by maternal body weight for small and giant BW groups only. When adjusted for weight, the accuracy of prediction within ± 1 day and ± 2 day intervals was 75 and 87%, respectively. Using stepwise logistic regression, the most accurate prediction of parturition date was obtained when fetuses were measured at 30 days after the LH surge, regardless of body weight or LS. Parturition date predictions made after 39 days of gestation using only biparietal and BD fetal measurements were $<50\%$ accurate within ± 2 days.

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1. Introduction

Early and accurate determination of canine gestational age using transabdominal ultrasonography is useful for predicting parturition date, management of parturition, and planning Cesarean section. Transabdominal ultrasonographic examination can be used to confirm pregnancy as early as 17 days after the luteinizing hormone (LH) surge [1–4]. The canine embryo grows at a linear rate of 1 mm in diameter per day from 17 to 30 days after the LH surge [5], after which the growth rate is exponential. In bitches of similar body weights, there is a significant relationship between gestational age and fetal measurements [6]. Transabdominal ultrasonographic examination has been used to predict parturition date in mid-gestation beagles [4], late-gestation Labrador Retrievers, and Golden Retrievers [7], as well as medium and small size dogs from mid to late gestation [8]. However, concerns have arisen regarding the use of this method for estimating gestational age in bitches of differing breed conformation [9] or those bearing small litters. No studies have been reported on the accuracy of this method in giant-sized (>40 kg) dogs or litters containing only one or two fetuses. We hypothesized that transabdominal ultrasonography would be an accurate method for prediction of parturition date in bitches of all body sizes with variable LS if the examinations were performed prior to the period of exponential fetal growth.

The objectives of this study were to determine the accuracy of the transabdominal ultrasonographic method in predicting parturition date from gestational age estimates based on fetal measurements published in two separate studies [4,7], and whether maternal body weight, LS, or gestational age at the time of examination had an effect on prediction accuracy.

2. Materials and methods

From 1985 to 2001, bitches presented as clinic patients and those in research breeding colonies were examined by transabdominal ultrasonography for pregnancy diagnosis (Radiology Service, Cornell University Hospital for Animals, College of Veterinary Medicine, Ithaca, NY). Prior to breeding, body weight of client-owned and research bitches was recorded during routine examinations by 4th year veterinary students, staff and faculty, and by research technicians, respectively. Body condition scores were not obtained but medical records indicated all bitches used in this study were in good health, neither excessively thin nor obese. Cases selected to participate in this retrospective study were those for which fetal measurements could be obtained from videotapes of the ultrasonographic examination, and delivery date of the first pup and LS were known from the medical record or direct communication with the owner. Pregnancies in which medical treatment was given prior to delivery of the first pup or an elective Cesarean section was performed were excluded from consideration for this study.

Bitches were examined in dorsal recumbency and were not sedated. Rubbing alcohol or transmission gel was applied copiously to the ventral abdomen, but the hair was not clipped. Two-dimensional, gray-scale, real-time ultrasound images were produced using mechanical and phase-array sector, linear and curved-linear transducers with frequencies from 5 to 12 mHz [Aloka 500 (Wallingford, CT), ATL 1000, 3000, and Ultramark IX (Bothell, WA), Hewlett-Packard 500 and 1000 (Palo Alto, CA)].

The uterus was located by moving the transducer cranially from the edge of the pubic bone, using the anechoic urinary bladder and crescent-shaped hyperechoic descending colon as landmarks. After examining the entire uterus, two fetuses that could be readily distinguished from each other were randomly selected for measurements. Two fetuses were measured for each examination, except when there was only one fetus present. Both fetuses selected for measurements were typically within the same horn and adjacent to each other. Adjacent fetuses were selected for measurement to avoid mistakenly measuring the same fetus twice. Position within the uterine horn (e.g. at the tip) or uterine body was not used as a selection criterion for choosing a fetus to be measured.

Fetal measurements were calculated to the nearest millimeter. Measurements were either taken at the time of examination using electronic calipers incorporated in the ultrasound apparatus or made from prints of the videotape examination using mechanical calipers and the centimeter scale on the margin of the ultrasound image. Fetal measurements were made by one sonographer without knowledge of the actual parturition date. From Days 20 to 25, embryonic vesicle diameter (EVD) is the only fetal measurement that can be made. For each examination, EVD was determined by taking the mean of two EVD measurements made at 90° angles from one side of the trophoblastic decidual reaction to the other (Fig. 1). The embryo becomes visible at Day 26 and from that day on, crown-rump length (CRL) and body diameter (BD) can be measured. From Days 26 to 29, CRL was measured as the total length of the embryo and BD was measured in the same plane (Fig. 1). Thereafter ($\geq$ Day 30), CRL was measured as a straight line from the most rostral

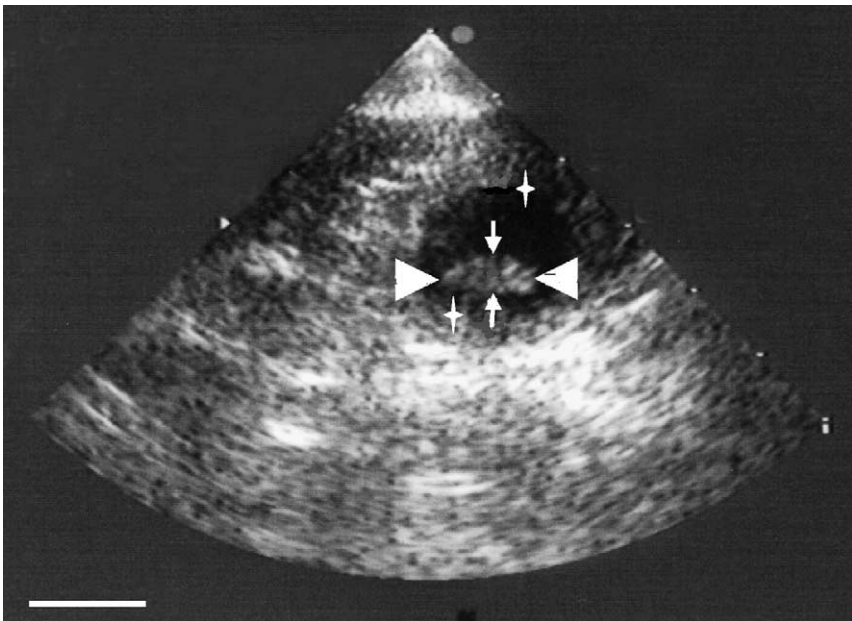


Fig. 1. Ultrasonographic image of a canine gravid uterus 29 days after the LH surge (Day 29). Embryonic vesicle diameter was measured from one side of the trophoblastic reaction to the other (star). The crown-rump length (arrowheads) was measured in the same plane as the body diameter (arrows). Bar = 1 cm.

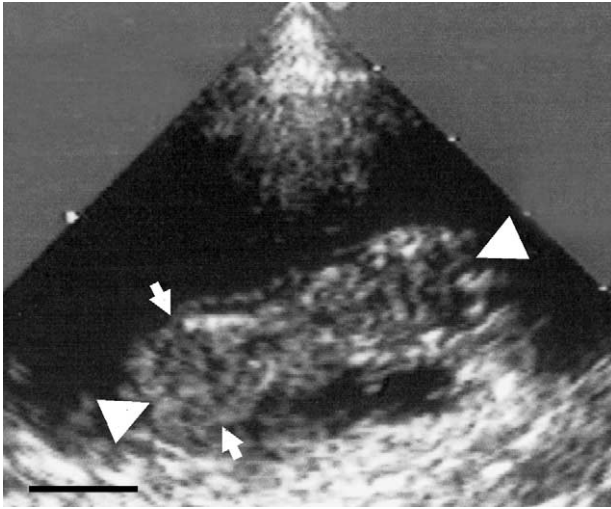


Fig. 2. Ultrasonographic image of a canine gravid uterus at 38 day after LH surge (Day 38). Head diameter (arrows) and crown-rump length (arrowheads) measurements could be made from this image. Bar = 1 cm.

point of the crown to the base of the tail [10] (Fig. 2) and BD was determined by taking the mean of two BD measurements made at 90° angles in the transverse plane at the level of the fetal liver and stomach (Fig. 3). Biparietal diameter (HD) was measured only at gestational ages in which the head could be clearly differentiated from the fetal body ($>$ Day 30) and

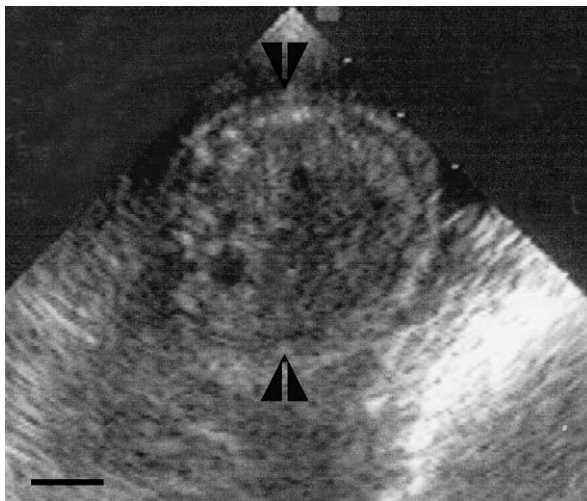


Fig. 3. Ultrasonographic image of a canine gravid uterus 46 days after the LH surge (Day 46). Body diameter (arrowheads) was measured with the fetus imaged in a transverse plane. The measurement was taken at the level of the fetal liver and stomach when these structures could be visualized. Bar = 1 cm.

was measured in the same plane as the CRL (Fig. 2). Once the fetal skeleton was visible (>Day 35), HD was the biparietal diameter. After fetal measurements were obtained, tables listing fetal measurements by gestational age for fetuses $\leq$ Day 43 [6] and $\geq$ Day 39 [7] were used to estimate the gestational age and parturition was predicted to occur on Day 65 as in Yeager et al. [4]. For fetuses between Days 39 and 43, both tables were used, generating two different parturition date predictions.

The overall accuracy of parturition date prediction was determined by calculating the difference between the actual and the predicted parturition dates ± 1 day and ± 2 days. Ultrasound examinations were divided into three groups: early gestation—Yeager and Concannon table (Days 20–30), mid gestation—Yeager and Concannon table (Days 31–43) and late gestation—England table (Days 39–62) to determine if gestational age at the time of examination or the fetal measurement table that was used influenced the accuracy of the prediction. The accuracy of parturition date prediction was compared between these three groups using χ^2 tests. To determine at which gestational age an ultrasound examination would yield the most accurate prediction of parturition date, a stepwise logistic regression was performed on the significance of association between gestational age and the likelihood of a correct prediction. To determine if body weight or LS influenced the accuracy of the prediction, ultrasound examinations were divided in groups by body weight: small (≤ 9 kg), medium (>9 – 20 kg), large (>20 – 40 kg), and giant (>40 kg). Within each BW group, LS mean and S.D. was calculated. Normal LS was defined as being within 1 S.D. of the mean for the BW group. Small and large LS were defined as less or greater than 1 S.D. from the mean, respectively. The accuracy of parturition date prediction between BW groups and between LS groups was compared using one-way ANOVA. Correction factors to adjust for small and giant body weights were calculated as the mean difference between the actual and predicted parturition date for that group. For all tests, Statistix[®] software (Analytical Software, St. Paul, MN) was used and the level of significance was considered at $P < 0.05$.

3. Results

One hundred and forty ultrasound examinations were performed on 83 bitches represented by 32 breeds with litter sizes (LSs) ranging from 1 to 14 (Table 1) and estimated gestational ages ranged from 20 to 62 days after the LH surge. Without respect to estimated gestational age at the time of examination, body weight or LS, the overall accuracy of predicting parturition date within the 65 ± 1 day and ± 2 day intervals was 63 and 81%, respectively. Although there was no significant difference in the accuracy of predicting parturition date between early and mid gestation using the fetal measurement table published by Yeager et al., predictions made from ultrasound examinations performed during late gestation using the fetal measurement table published by England et al. were significantly less accurate (Table 2). Logistic regression analysis demonstrated that a significant association exists between the gestational age at the time of an ultrasound examination and the likelihood of a correct prediction of parturition date, with the most accurate predictions occurring at Day 30 using EVD, CRL, and BD measurements.

Table 1

Ultrasound examinations were divided into four categories based on nonpregnant maternal body weight (BW): small (≤ 9 kg), medium (>9 – 20 kg), large (>20 – 40 kg), and giant (>40 kg)

BW groups	Breed	N_E	N_P	N_B	LS range	Mean LS (S.D.)
Small	Border Terrier	11	6	5	1–7	4 (2)
	Boston Terrier	4	4	4		
	Dachshund	2	2	2		
	Jack Russell Terrier	3	2	2		
	Scottish Terrier	9	3	2		
	Tibetan Spaniel	8	8	4		
	Tibetan Terrier	2	2	1		
	Wirehaired Fox Terrier	1	1	1		
Medium	Basenji	2	1	1	1–12	6 (3)
	Australian Shepherd	1	1	1		
	Beagle	3	3	3		
	Bearded Collie	1	1	1		
	Boxer	1	1	1		
	Brittany Spaniel	1	1	1		
	English Setter	1	1	1		
	Samoyed	1	1	1		
	Shetland Sheepdog	5	3	2		
	Springer Spaniel	1	1	1		
	Standard Poodle	3	3	3		
Large	Bulldog	1	1	1	1–13	7 (3)
	Doberman	8	3	3		
	German Shepherd dogs	15	12	7		
	German Shorthaired Pointer	2	2	1		
	Golden Retriever	3	3	3		
	Irish Setter	1	1	1		
	Labrador Retriever	20	15	11		
	Siberian Husky	2	2	2		
Giant	Filia Brasileira	5	4	3	2–14	8 (4)
	Great Dane	5	4	4		
	Newfoundland	14	13	8		
	Rottweiler	3	1	1		
	Staffordshire Terrier	1	1	1		
Total	32 breeds	140	107	83	1–14	

N_E : number of ultrasound examinations, N_P : number of pregnancies, N_B : number of bitches, LS: litter size.

For ultrasound examinations performed on medium and large BW bitches, body weight did not affect the accuracy of parturition date prediction. However, the prediction was less accurate for examinations performed on small and giant BW bitches when compared to those in the medium and large BW groups (Table 3). The difference between actual and predicted parturition dates within the small and giant BW groups was $+1.42$ and -2.44 days, respectively. LS had no effect on the accuracy of parturition date prediction within the 65 ± 1 day or ± 2 day interval (Table 4).

Table 2

Gestational age at which the examination was performed had an effect on the accuracy of parturition date prediction

	Groups			
	Early gestation	Mid gestation	Late gestation	Overall
Days after the LH surge	20–30	31–43	39–62	20–62
Source of fetal measurements	Yeager and Concannon [6]	Yeager and Concannon [6]	England et al. [7]	
65 ± 1 day interval (%)	75	66	43*	63
65 ± 2 day interval (%)	88	82	53*	81
Examinations (n)	56	54 ^a	43 ^a	140

Ultrasound examinations were grouped by gestational age at the time of examination to predict parturition date, irrespective of maternal body weight or litter size.

* Indicates values significantly different in comparison to other groups ($P < 0.05$).

^a Thirteen gestational age determinations were made from examinations occurring between 39 and 43 days of gestation. Both Yeager and Concannon [6] and England et al. [7] fetal measurement tables were used for these examinations.

Table 3

Maternal body weight (BW) had an effect on the accuracy of parturition date prediction

Accuracy of parturition date prediction	Maternal BW groups				
	Small	Medium	Large	Giant	Overall
65 ± 1 day interval (%)	55*	71	78	39*	63
65 ± 2 day interval (%)	75*	86	90	61*	81
65 ± 1 day interval (%) adjusted for body weight	73			62	75
65 ± 2 day interval (%) adjusted for body weight	85			81	87
Examinations (n)	40	20	52	28	140

Ultrasound examinations were grouped by body weights irrespective of gestational age at the time of examination. Results indicate that a correction factor of +1 and –2 days should be applied to gestational age predictions of bitches within the small and giant BW groups, respectively.

* Indicates prediction was significantly more accurate ($P < 0.05$) for medium and large body weights when compared to small and giant body weights.

Table 4

Litter size (LS) did not have an effect on the accuracy of parturition date prediction

Accuracy of parturition date prediction	LS groups			
	Small	Average	Large	Overall
65 ± 1 day interval (%)	56	66	67	63
65 ± 2 day interval (%)	76	83	83	81
Examinations (n)	25	97	18	140

Ultrasound examinations were grouped by LS for each maternal BW group irrespective of gestational age at the time of examination.

4. Discussion

An accurate prediction of parturition date can be made using transabdominal ultrasonography irrespective of LS and maternal body weight, if correction factors are used for small and giant breeds. A correction factor of +1 day should be applied to the gestational age prediction for small body weight (<9 kg) bitches and –2 days for giant body weight (>40 kg) bitches. For example, if the gestational age was determined to be Day 30 for a bitch of >40 kg, the gestational age corrected for maternal body weight would be Day 28. After adjusting for body weight in the small and giant BW groups, the accuracy of parturition date prediction for all bitches within the 65 ± 2 day interval was 87%.

The most accurate predictions of parturition date were obtained when fetuses were measured at Day 30. Predictions of parturition date could not be made accurately in late gestation when the fetal measurements published by England et al. were used. The decline in prediction accuracy in late gestation is probably due to variability in fetal growth rates across breeds at this time [6]. EVD increases linearly at a rate of 1 mm/day from Days 17 to 30 [5]. After this, the growth rate is exponential. However, results of this study also indicate that fetal growth rate is different in pregnant bitches at the extreme ends of body weight range (≤ 9 and >40 kg). Previous studies have shown that there is no difference in gestation length between bitches of differing body weight [11]. Results of this study support that finding and indicate that fetuses of small BW bitches grow at a slower rate, and fetuses of giant BW bitches grow at a faster rate than those of medium or large BW bitches.

Accurate predictions of canine parturition date can be made within a 65 ± 2 day interval. In comparison to using preovulatory progesterone concentrations to predict parturition date by identifying the initial rise in progesterone [11], transabdominal ultrasonography has similar prediction accuracy but requires technical skill and the use of correction factors for small and giant BW bitches. Using a McNemar's χ^2 test, a high correlation exists between the two methods for predicting parturition date ($P = 1.00$). In our clinical and research experience, the transabdominal ultrasonography method has been useful to confirm parturition date prediction by the preovulatory progesterone method [11] and is particularly valuable in predicting parturition date when such data are unavailable or equivocal.

Accurate estimation of parturition date by this method should be useful to clinicians in making decisions regarding elective Cesarean sections by providing a date at which a pregnancy can be safely considered full term. Furthermore, this method should allow clinicians to document premature births and determine the earliest premature delivery date that is compatible with pup survival. In summary, to make an accurate prediction of parturition date using transabdominal ultrasonography, it is important to perform the examination near Day 30 of gestation, measure two fetuses, unless only one fetus is present, and adjust the gestational age estimate to correct for small (+1 day) or giant (–2 days) BW bitches.

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