

Association between inter puppy interval at whelping and stillbirth risk

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Prolonged interval between puppy births increases the risk of the subsequent puppy being stillborn. There are general guidelines of what constitutes a normal inter-puppy interval (IPI) but there are no studies quantifying the change of stillbirth risk at these time points. Our objectives were to: 1) identify the optimal threshold for IPI associated with stillbirth and report the performance of the commonly used threshold of 2-4 hours; and 2) determine if covariates such as birth order and sex of puppy are associated with stillbirth risk. We hypothesize that 1) the optimal threshold for IPI is between the 1-4 hours with a tradeoff between over diagnosis of puppies at increased stillbirth risk and missing puppies that will be stillborn as the IPI threshold increases; and 2) covariates such as birth order affects stillbirth rates.

Study design

Retrospective study was performed using whelping data from a guide dog colony. Birth outcome (stillborn or born alive) was used as the dependent variable. Covariates evaluated included: sex of the puppy, birth order, if the puppy was the last pup in the litter, litter size, breed and total whelp time. The IPI cannot be determined for the first puppy born in a litter and these were excluded from the analyses. Association between stillbirth and IPI was evaluated using logistic regression (JMP Pro ver 13) and the optimal threshold for IPI was determined by Receiver Operator Characteristics (ROC) curve. The effect of birth order on stillbirth risk was evaluated using mixed-model ANOVA (PROC GLIMMIX of SAS ver 9.4). Covariates were evaluated individually and offered to the final model if $P < 0.10$ and retained if $P < 0.05$.

Results

A total of 3,594 puppies from 493 litters were evaluated and the stillbirth rate was 6.6%. Puppies that were born live had lower median and mean IPI (32 and 47 minutes) compared with stillborn puppies (65 and 102 minutes). ROC analysis showed the optimal IPI threshold to identify stillborn puppy was 62 minutes (area under the curve=61%) with a positive predictive value (PPV)=14.5% and the negative predictive value (NPV)=95.9%. Puppies with an inter pup interval of >60 minutes were 3.7 times more likely to be stillborn with PPV=13.5% and NPV=95.9% at this threshold. The odds ratio for being stillborn was 5.9, 4.7 and 9.3 respectively for puppies with an IPI of >120 minutes (PPV=28.4%, NPV=93.7%), >180 minutes (PPV=31.8%, NPV=94.5%), and >240 minutes (PPV=36.5%, NPV=94.2%). The final model for stillbirth retained IPI, birth order, being the last puppy in the litter, and sex of the puppy. Male puppies are 34% more likely to be stillborn compared with female pups; birth order was significantly associated with stillbirth; and surprisingly the last puppy in the litter were 2.4 times more likely to be stillborn even after controlling for birth order.

Discussion/conclusion

The optimal threshold for IPI in our dataset was 62 minutes which is lower than the 2-4 hours typically accepted as normal. When making decision to intervene during whelpings, the PPV is more useful than NPV as the PPV informs us the likelihood that the puppy with IPI >62 minutes has a probability of 14.5% to be stillborn and increases to 36.5% when IPI >240 minutes. The high NPV just mean the puppy born within 62 minutes from the previous puppy has a 95.9% probability to be alive but even for the 4.1% stillborn puppy with the low IPI, there is no action to be taken. The proportion of female puppies that were stillborn was 5.8% compared with 7.3% in male puppies but the last puppy in the litter, regardless of litter size has a stillbirth rate of 18.7% compared with non-last puppies at 4.6%. Male pups and more importantly, last pups in the litter were at higher risk of stillbirth.

Keywords: Canine, stillbirths, inter puppy interval, birth order