

Comparison of neonatal puppy vitality following elective cesarean section with different induction agents and epidural anesthesia

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Summary

The vitality and survival rate of newborn puppies delivered by cesarean section (CS) remain suboptimal. One key factor influencing CS outcomes is the anesthesia protocol used for the mother during the procedure. Typically, the effects of anesthesia on newborns are assessed using the Apgar scale. However, this scoring system may lack the sensitivity to detect subtle differences between anesthetic protocols. The primary goal of the study was to compare the mentioned CS protocols by analyzing the individual parameters that make up the Apgar score. The study enrolled 49 bitches scheduled to planned cesarean section divided into three groups. In the PROP and EPI groups, general anesthesia was induced using propofol. Anesthesia was then maintained with isoflurane in oxygen. Additionally, in the EPI group, an epidural block was administered using lidocaine. The final Apgar scores in newborns from ALFA, PROP, and EPI groups showed no significant differences. However, analysis of the individual components of the clinical examination revealed differences in the puppies' overall condition. Puppies in the ALFA group had a heart rate of 130.6 ± 37.9 beats per minute, which was significantly higher than that of the PROP and EPI groups (113.38 ± 46.0 and 112.10 ± 53.5 beats per minute, respectively). Additionally, a greater number of puppies in the ALFA group had pink-red mucous membranes compared to those in the other groups. Furthermore, puppies in the ALFA group received a higher average score for respiratory rate, even though the majority of pups across all three groups fell into the < 6 breaths per minute category. In summary, puppies in the ALFA group demonstrated greater hemodynamic stability, characterized by a higher heart rate (HR) and improved peripheral perfusion.

Keywords: cesarean section, anesthesia, Apgar scores

In cases of difficult labor, the life and health of fetuses – and subsequently neonates – are at high risk due to obstetric complications and related health issues that may affect their well-being and survival. Furthermore, birth complications often require resolution through a cesarean section (CS). In such cases, anesthesia and surgical management become critical factors determining neonatal survival. The primary goal of a professionally performed cesarean section is to provide newborns with the best possible start to extrauterine life, comparable to that of natural birth.

Similar to human medicine, CSs in dogs are becoming increasingly common due to advancements in veterinary medicine and improved standards of care. However, scientific data on canine fetal physiology, the transition period, and early neonatal care and treatment remain limited compared to human medicine. It is known that fetal physiology is significantly different in the uterus compared to after the puppies are extracted. In fetal life, circulation between oxygen, carbon dioxide, nutritional ingredients, and their substrates occurs between the fetus and the dam's body through placental

circulation. Once the puppy is delivered, the neonate must undergo immediate adaptation to independent functioning from the very first minute. It is crucial to examine neonatal vitality at this point, as it helps detect any abnormalities at an early stage and evaluate its chance of survival. Initial examination of newborns involves a brief assessment of vital parameters, including heart rate (HR), respiration (rate and effort), mucous membrane color (MM), response to stimulation, and muscle tone. This survey allows for the rapid detection of hemodynamic compromise, including cyanosis, hypoperfusion, bradycardia, hypotonia, respiratory depression, and apnea (26). These examinations also constitute the components of the Apgar scale (26) which has been modified and improved over the years. The Apgar scoring system has also been appropriately modified to assess newborn animals, including dogs. Currently, one of the most popular and widely used scale in small animal practice is the one developed and modified for dogs by Veronesi et al. (2-5, 7, 9, 10, 16, 18, 28, 29). However, this is not the only system used to evaluate newborn dogs (6, 12, 15, 17, 20, 21, 25, 30). There is no consensus among authors on the threshold values of the tested parameters that determine the points awarded. For this reason, to assess the effect of maternal anesthesia in this study, we decided to analyze the individual components of the clinical trial. Additionally, this approach will enable the detection of subtle differences between protocols.

On the other hand, the anesthetic protocol is the main factors affecting the final outcome of a cesarean section. Since all sedatives and anesthetics cross the blood-placenta barrier, maternal anesthesia directly and indirectly influences the survival and viability of newborns (9, 11, 15, 17, 21, 30). There are various drugs available for use as surgical analgesics and anesthetics, but many can have a fatal impact on newborn survival. As a result, veterinary obstetricians often have limited options when selecting pharmacological agents for Cesarean sections to avoid jeopardizing the health and life of the newborns. Currently, propofol is the most frequently used drug for induction prior to a cesarean section, highly valued for its rapid redistribution and metabolism (22, 24). In human medicine, often after inducing anesthesia with propofol, an additional neuraxial block is administered through epidural anesthesia using lidocaine. However, there is ongoing consideration as to whether alfaxalone could be a safer alternative for induction of anesthesia during cesarean section in dogs. Alfaxalone causes minimal depression in the cardiovascular and respiratory systems, suggesting higher safety (8, 14, 19, 27, 31). Regardless of the induction of anesthesia, the prevailing method of CS is to use induction and maintenance agents that minimize depression of the cardiovascular and central nervous systems. In everyday practice, determining which available medications have the least impact on

neonatal health and ensure the highest survival rate is challenging. Such conclusions require thorough clinical evaluations and comparative studies to establish the safest anesthetic protocol for canine newborns delivered via CS. Therefore, as a first step in this direction, the aim of this study was to compare the effects of different induction agents and epidural component to determine which provides the greatest benefit for the viability of newborn puppies delivered via CS. The clinical findings from this study would contribute to reducing the incidence of puppies with impaired quality of life in the initial hours post-delivery, which in some cases may ultimately lead to death. Finally, a critical comparison of the obtained results will enable the proposal of a novel approach to the anaesthetic protocol for cesarean section in dogs.

Material and methods

Animals. The study examined 49 privately owned female dogs scheduled for planned cesarean sections. The timing of the procedure was determined by monitoring progesterone levels during estrus, identifying the luteinizing hormone (LH) surge, and scheduling the CS approximately 63-64 days after the detected LH peak. Before undergoing the procedure, each dog underwent a thorough clinical evaluation to confirm eligibility for elective surgery. Pregnancy progression was monitored weekly via ultrasound (US) from confirmation until the anticipated delivery date. On the 63rd day post-LH peak, a comprehensive reproductive assessment was performed, which included evaluating milk production and conducting a detailed pregnancy scan to assess fetal heart rate and gastrointestinal motility. Based on these findings, the cesarean section was either conducted that day or postponed to the following day. The final decision regarding the elective CS was made solely by the veterinarian performing the surgery, based strictly on clinical assessments and independent of the study. All procedures and eligibility criteria adhered to Good Clinical Practice (GCP) guidelines.

Anesthetic protocols. On the day of surgery, the dams were randomly assigned to one of three groups: ALFA (n = 16), PROP (n = 18) and EPI (15). None of the groups received premedication, and all dams were given meloxicam (0.2 mg/kg subcutaneously, Metacam 5 mg/ml, Boehringer Ingelheim, Poland) approximately 30 minutes before anesthesia induction.

In the PROP and EPI groups, general anesthesia was induced using propofol (Propofol-Lipuro, 10 mg/ml, B. Braun Melsungen AG, Germany) intravenously at an initial dose of 3 mg/kg, adjusted as needed to allow tracheal intubation. Anesthesia was then maintained with isoflurane (IsoVet, Piramal Healthcare, United Kingdom) in oxygen. Additionally, in the EPI group, an epidural block was administered using lidocaine at a dose of 3 mg/kg (Lignocainum Hydrochloricum WZF 2%, Polfa Warszawa, Poland).

For the ALFA group, anesthesia was induced with alfaxalone at a dose of 2-3 mg/kg, titrated to effect (Alfaxan Multidose, 10 mg/ml, Jurox, Dublin, Ireland). Similar to the other groups, anesthesia was maintained with isoflurane.

Following the removal of the last puppy, all dams received intravenous methadone (0.2 mg/kg, Comfortan, Eurovet Animal Health BV, Netherlands). Fluid therapy was administered at a rate of 5 ml/kg/h (Optilyte, Fresenius Kabi Poland), with adjustments made in response to drops in blood pressure by either increasing the infusion rate or administering a bolus of 3-5 ml/kg.

Surgical procedure. Cesarean sections were performed with a standard midline approach. The surgical site was clipped and aseptically prepared. The dams were then positioned in dorsal recumbency. A midline incision was made along the linea alba, beginning just behind the umbilicus and extending caudally toward the pubis. The incision length depended on the size of the uterus and the number of fetuses. The subcutaneous tissue and fascia were carefully dissected to expose the peritoneum, which was then incised to access the abdominal cavity. The gravid uterus was identified and gently exteriorized to improve surgical access. A single incision was made in the uterine body, after which the fetal membranes were ruptured. Each puppy was immediately handed to an assistant for resuscitation, care, and Apgar evaluation. Once all newborns were removed, the uterus was inspected for hemorrhage, retained fetal membranes, or placenta and was then sutured using a single continuous pattern (Monosyn® 3/0, B. Braun Aesculap Chifa Sp. z o.o., Nowy Tomyśl, Poland). Before closure, the abdominal cavity was flushed with warm saline. The abdominal wall, subcutaneous tissue, and skin were routinely closed using synthetic absorbable material.

Neonatal assessment and Apgar scoring (AS). The Apgar assessment was conducted by the same experienced staff member throughout the study. A modified Apgar scoring system, specifically adapted for canine neonates, was utilized (29). The initial evaluation took place immediately after birth, before any neonatal interventions were applied (0 min). The following reference ranges were used for Apgar scoring: heart rate (HR): > 220 bpm (2 points), 180-220 bpm (1 point) to < 180 (0 points); respiration rate (RR): > 15 breaths per minute (2 points), 6-15 (1 point) to < 6 (0 points); the irritability reflex detected after gentle compression of a tip of a paw – was evaluated based on the degree of reaction: crying and quick leg retraction (2 points), weak leg retraction and no or just weak vocalization (1 point), and no leg retraction and no vocalization (0 points); spontaneous movement of a newborn: 2 – strong movement, 1 – weak movement, and 0 – absent; mucous membranes color: dark pink (2 points), light pink (1 point) and pale to cyanotic (0 points). Total points received provided the final Apgar score: 7-10, no distress, healthy newborns; 4-6, moderate distress, weak newborn and 0-3, severe distress, critical newborns.

Tab. 1. General data and total time of anesthesia in bitches undergoing C-section

Parameter	ALFA	PROP	EPI
No of puppies	69	70	67
No of puppies per litter	5.11 ± 2.95	4.53 ± 2.72	4.81 ± 2.95
Females % (no)	49.2 (34)	40.5 (28)	59.1 (39)
Males % (no)	50.8 (35)	59.5 (42)	40.9 (27)
Body weight (g)	287.05 ± 148.34	350.47 ± 137.76	273.15 ± 111.51
Female body weight (g)	276.96 ± 161.86	349.82 ± 135.17	277.82 ± 119.15
Male body weight (g)	265.00 ± 132.29	350.90 ± 141.08	266.40 ± 101.29

Tab. 2. The number of puppies participating in the experiment divided into groups, gender and body weight. No statistically significant differences were found either within or between groups

	ALFA	PROP	EPI	p-value (Kruskal-Wallis ANOVA)
No of females	16	18	15	
Parameter	Mean, SD			
Female age (years)	3.81 ± 1.75	3.82 ± 1.63	4.22 ± 2.07	0.76
Body weight (kg)	28.04 ± 19.69	13.00 ± 10.20	16.71 ± 23.45	0.06
Total time (min)	64.39 ± 14.29	54.33 ± 14.63	53.39 ± 13.22	0.03

Results and discussion

Data on the age and body weight of the females in the study, along with the total anesthesia duration, are presented in Table 1. Puppy data, including litter size, sex, and birth weight, are shown in Table 2. There were no statistically significant differences in puppy body weight or gender, either within or between groups.

The final Apgar scores in the ALFA, PROP, and EPI groups showed no significant differences, with values of 3.3 ± 2.1 , 2.5 ± 1.9 , and 3.4 ± 2.0 , respectively ($p > 0.05$, Fig. 1). However, when analyzing the individual components of the final assessment, significant

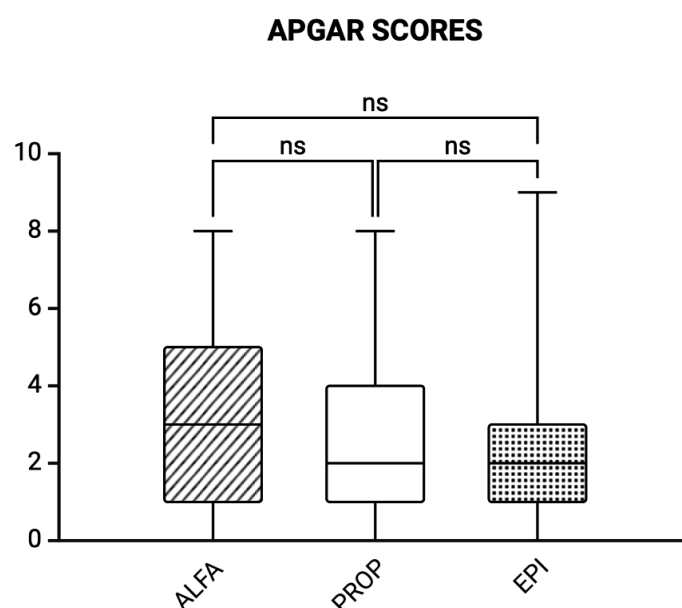


Fig. 1. Box plot of Apgar scores of puppies in ALFA, PROP and EPI groups at 0 minutes of life

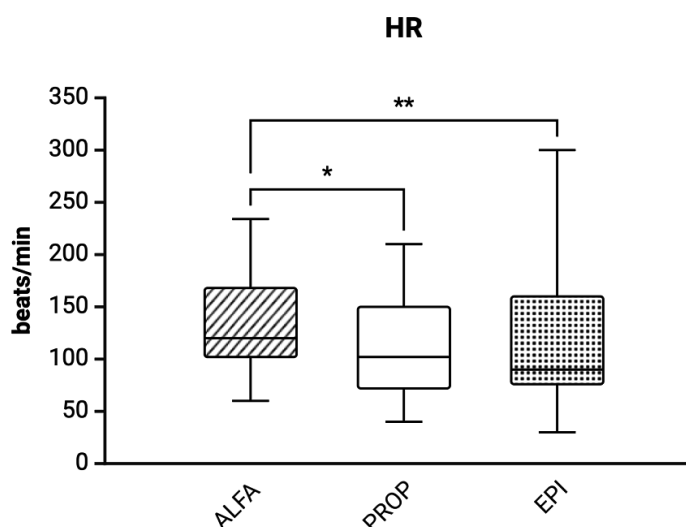


Fig. 2. Box plot of heart rate of puppies in ALFA, PROP and EPI groups at 0 minutes of life

Explanations: * indicates statistical significance at $p = 0.01$; ** indicates statistical significance at $p = 0.006$

differences were observed. Puppies in the ALFA group had the heart rate of 130.6 ± 37.9 beats per minute, which was significantly higher than that of the PROP and EPI groups (113.38 ± 46.0 and 112.10 ± 53.5 beats per minute, respectively) (Fig. 2). However, no differences were found when analyzing the scores assigned based on clinical examination results (Tab. 3).

Tab. 3. The mean and standard deviation scores for newborns in different groups for individual parameters in the Apgar assessment

	HR	RR	MMC	Tonus	Reaction
ALFA	0.19 ± 0.43	0.85 ± 0.83^a	1.13 ± 0.42^a	0.53 ± 0.56	0.83 ± 0.72
PROP	0.15 ± 0.43	0.58 ± 0.77	0.61 ± 0.57^b	0.49 ± 0.58	0.68 ± 0.79
EPI	0.20 ± 0.47	0.50 ± 0.75^b	0.53 ± 0.56^b	0.56 ± 0.61	0.58 ± 0.75

Explanations: HR – heart rate; RR – respiratory rate; MMC – mucous membrane color; a, b – different superscriptions within the column denote statistically significant difference ($p < 0.05$)

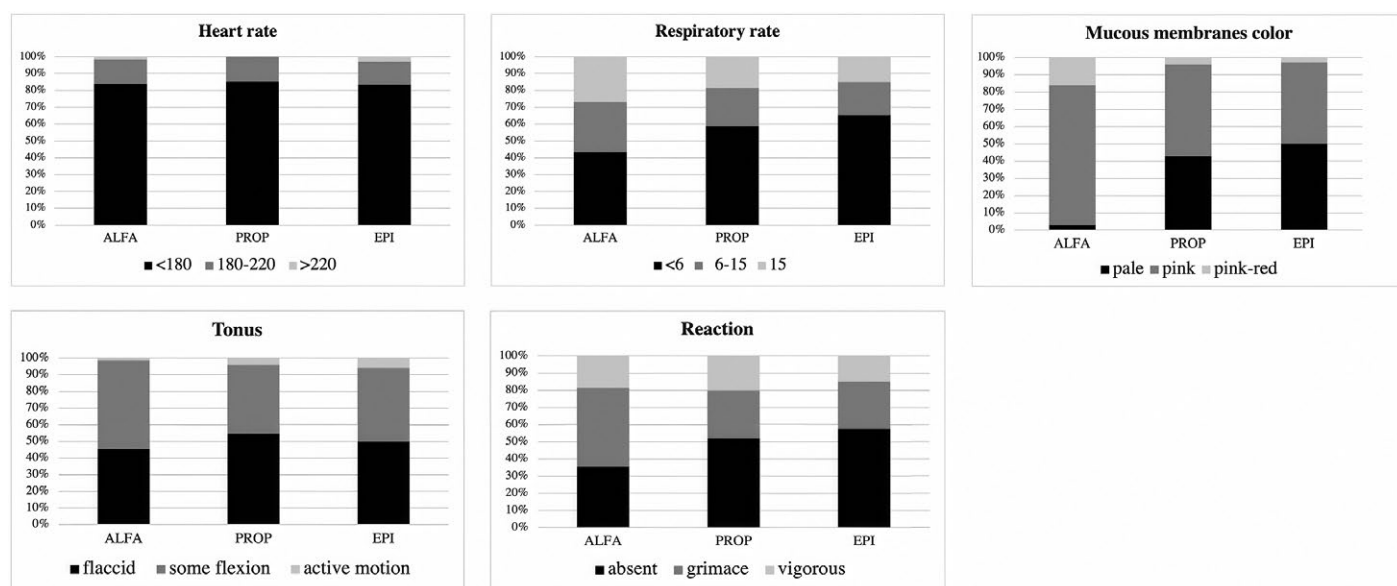


Fig. 3. Percentage of puppies classified into different categories based on individual neonatal assessment parameters

Statistical analysis revealed that anesthetic protocol affects also mucous membrane color ($p = 0.00001$). In the PROP and EPI groups, 42.7% and 50% of newborns were pale, while only 4% and 3%, respectively, had a normal red-pink coloration. In contrast, in the ALFA group, only 3% of newborns were pale, whereas 16.2% displayed a healthy pink-red color (Fig. 3). Additionally, the mean scores for mucous membrane coloration differed among PROP, EPI and ALFA puppies, with values of 0.61 ± 0.57 , 0.53 ± 0.56 , and 1.13 ± 0.42 , respectively (Tab. 3). The differences were also found in mean scores for respiratory rate between ALFA and EPI group.

In cases of complicated labor, obstetric complications pose significant risks to fetal and neonatal health, often necessitating cesarean section. The success of this procedure, particularly anesthesia and surgical management, is critical for neonatal outcomes, ensuring a transition to extrauterine life comparable to natural birth. However, determining the safest anesthetic protocol for minimizing neonatal depression and maximizing survival remains challenging and requires thorough clinical evaluation. As a first step, this study aimed to compare the effects of different induction agents and an epidural component to identify the most beneficial approach for newborn viability measured by Apgar scores.

The mean Apgar scores of the evaluated puppies ranged from 2.5 to 3.4, regardless of the anesthetic protocol used, indicating a comparable risk among the three anesthesia methods during CS. While overall Apgar scores were similar across groups, a detailed analysis of individual score components revealed significant differences

based on the type of induction agent or the addition of an epidural component.

The main differences were observed in heart rate, respiratory rate and mucous membrane coloration. Puppies from ALFA group had a significantly higher heart rate (130 bpm vs 112-113 bpm in the remaining PROP and EPI groups), with the average Apgar score for this parameter was only 0.19 ± 0.43 , similar to the scores in the PROP (0.15 ± 0.43) and EPI (0.20 ± 0.47) groups. Despite the highest heart rate results in the ALFA group, only one pup achieved a total score of 2 points, indicating a heart rate above 220 beats per minute. The vast majority of evaluated puppies scored 0, as their heart rates were below 180 beats per minute. Furthermore, the mean respiratory rate scores were statistically different between ALFA and EPI (0.85 ± 0.83 and 0.50 ± 0.75 , $p < 0.05$, respectively). However, both groups had values below 1, indicating that all puppies were classified into the same category (< 6 breaths/min). Finally, the mucous membrane color differed in the group of neonates whose mothers received alfaxalone, with significantly more puppies displaying red-pink or pink mucous membranes and fewer pale neonates. As a result, the average score for this parameter was 1.13 ± 0.42 , compared to 0.61 ± 0.57 in the PROP group and 0.53 ± 0.56 in the EPI group with significant difference. To summarize, puppies from the ALFA group appeared more hemodynamically stable, exhibiting a higher heart rate (HR) and better peripheral perfusion. On the other hand, both propofol as the induction agent and epidural anesthesia similarly reduced heart rate in the newborns. These results are in agreement with our previous report where we obtained no differences in Apgar scores at 0 minutes between pups delivered from bitches anesthetized with and without epidural component during CS (4).

The available literature contains varying reports on how alfaxalone affects newborn viability. Metcalfe et al. (17) found no differences in puppies vitality in the first minute of life when comparing propofol and alfaxalone as induction agents for the mothers. On the other hand, Doebeli et al. (9) reported higher Apgar scores in ALFA group, similar as Meladri et al. (16) and Rogrigez-Tujilo (21). Vilar et al. (30) compared three anesthetic protocols: propofol, propofol plus sevoflurane, and propofol with sevoflurane plus epidural anesthesia. The best minute-after-birth assessment results were observed in puppies whose mothers received epidural anesthesia. Unfortunately, the authors used different scoring systems, none of which provided a breakdown of the individual classification components. As a result, comparing our findings with those of other researchers is challenging.

To date, there is no information available on the extent to which alfaxalone and propofol cross the placenta in canines. However, numerous studies have compared their hemodynamic effects in adult dogs (1, 23) proved

that propofol induction results in a short-term reduction in mean arterial pressure (MAP), whereas alfaxalone induction preserves MAP and cardiac output by significantly increasing heart rate. Moreover, blood pressure in patients induced with propofol compared to alfaxalone was significantly lower (1). Based on the results of our study, it can be concluded that a similar clinical effect was observed in newborns whose mothers were anesthetized with either propofol or alfaxalone.

On the other hand, lidocaine used for epidural block acts locally and does not cross the placenta, meaning it has no direct impact on the fetus or fetuses (13). Therefore, puppies from the EPI group exhibited similar vital parameters to that of PROP newborns, showing lower heart rates and poorer peripheral perfusion compared to the ALFA group.

Despite significantly better examination results, puppies from the ALFA group did not score higher on individual parameters and were classified in the same category as PROP and EPI puppies. As a result, there were no differences in the final Apgar score.

Despite the absence of differences in the final Apgar score, the maternal anesthesia protocol significantly influenced the newborns' viability, with the best outcomes observed in the ALFA group. Since the applied assessment system did not detect differences in the newborns' condition, the authors suggest that the higher heart rate (HR) and better peripheral perfusion seen in the ALFA group of puppies could be attributed to the typical pharmacodynamics of alfaxalone, which does not reduce cardiovascular function (1, 23). Moreover, all puppies survived the first two weeks of life without supportive treatment, suggesting that the lower HR values recorded in PROP and EPI groups did not pose a risk to puppy health or survival. Hence, although alfaxalone improves circulation, it should be used with caution, as our results indicate it does not provide a significant protective effect during the initial extrauterine life of newborns. Furthermore, our findings show that all three anesthetic protocols tested are safe for puppies, and none of the drugs compared had a more beneficial impact on health or survival during cesarean sections in dogs.

References

1. Amengual M., Flaherty D., Auckburally A., Bell A. M., Scott E. M., Pawson P.: An evaluation of anaesthetic induction in healthy dogs using rapid intravenous injection of propofol or alfaxalone. *Veterinary Anaesthesia and Analgesia* 2013, 40, 115-123.
2. Antończyk A., Kielbowicz Z., Niżański W., Ochota M.: Comparison of 2 anesthetic protocols and surgical timing during cesarean section on neonatal vitality and umbilical cord blood parameters. *BMC Vet. Res.* 2023, 19, 48.
3. Antończyk A., Kielbowicz Z., Niżański W., Ochota M.: Preliminary study on fluid bolus administration for prevention of spinal hypotension in dogs undergoing elective cesarean section. *Front Vet. Sci.* 2023, 10, 1112845.
4. Antończyk A., Ochota M.: Is an epidural component during general anaesthesia for caesarean section beneficial for neonatal puppies' health and vitality? *Theriogenology* 2022, 187, 1-8.
5. Antończyk A., Ochota M., Niżański W.: Umbilical cord blood gas parameters and Apgar scoring in assessment of new-born dogs delivered by cesarean section. *Animals (Basel)* 2021, 11, 685.

6. Batista M., Moreno C., Vilar J., Golding M., Brito C., Santana M., Alamo D.: Neonatal viability evaluation by Apgar score in puppies delivered by cesarean section in two brachycephalic breeds (English and French bulldog). *Anim. Reprod. Sci.* 2014, 146, 218-226.
7. Cramer K. G. M. de, Joubert K. E., Nöthling J. O.: Puppy survival and vigor associated with the use of low dose medetomidine premedication, propofol induction and maintenance of anesthesia using sevoflurane gas-inhalation for cesarean section in the bitch. *Theriogenology* 2017, 96, 10-15.
8. Dehuysser V., Bosmans T., Kitshoff A., Duchateau L., de Rooster H., Polis I.: Cardiovascular effects, induction and recovery characteristics and alfaxalone dose assessment in alfaxalone versus alfaxalone-fentanyl total intravenous anaesthesia in dogs. *Veterinary Anaesthesia and Analgesia* 2017, 44, 1276-1286.
9. Doebeli A., Michel E., Bettschart R., Hartnack S., Reichler I. M.: Apgar score after induction of anesthesia for canine cesarean section with alfaxalone versus propofol. *Theriogenology* 2013, 80, 850-854.
10. Fusi J., Faustini M., Bolis B., Veronesi M. C.: Apgar score or birthweight in Chihuahua dogs born by elective cesarean section: which is the best predictor of the survival at 24 h after birth? *Acta Veterinaria Scandinavica* 2020, 62, 1-8.
11. Grimm K. A., Lamont L. A., Tranquilli W. J., Greene S. A., Robertson S. A.: *Veterinary anesthesia and analgesia: The fifth edition of Lumb and Jones.* Wiley 2015.
12. Groppetti D., Di Cesare F., Pecile A., Cagnardi P., Merlanti R., D'Urso E. S., Gioeni D., Boracchi P., Ravasio G.: Maternal and neonatal wellbeing during elective C-section induced with a combination of propofol and dexmedetomidine: How effective is the placental barrier in dogs? *Theriogenology* 2019, 129, 90-98.
13. Jones R. S.: Epidural analgesia in the dog and cat. *The Veterinary Journal* 2001, 161, 123-131.
14. Keates H., Whitem T.: Effect of intravenous dose escalation with alfaxalone and propofol on occurrence of apnoea in the dog. *Res. Vet. Sci.* 2012, 93, 904-906.
15. Luna S. P. L., Cassu R. N., Castro G. B., Teixeira Neto F. J., Silva Júnior J. R., Lopes M. D.: Effects of four anaesthetic protocols on the neurological and cardiorespiratory variables of puppies born by cesarean section. *Vet. Rec.* 2004, 154, 387-389.
16. Melandri M., Alonge S., Peric T., Bolis B., Veronesi M. C.: Effects of alfaxalone or propofol on Giant-Breed Dog neonates viability during elective cesarean sections. *Animals* 2019, 9, 962.
17. Metcalfe S., Hulands-Nave A., Bell M., Kidd C., Pasloske K., O'hagan B., Perkins N., Whitem T.: Multicentre, randomised clinical trial evaluating the efficacy and safety of alfaxalone administered to bitches for induction of anaesthesia prior to caesarean section. *Australian veterinary journal* 2014, 92, 333-338.
18. Mila H., Grellet A., Delebarre M., Mariani C., Feugier A., Chastant-Maillard S.: Monitoring of the newborn dog and prediction of neonatal mortality. *Prev. Vet. Med.* 2017, 143, 11-20.
19. Muir W., Lerche P., Wiese A., Nelson L., Pasloske K., Whitem T.: Cardiorespiratory and anesthetic effects of clinical and supraclinical doses of alfaxalone in dogs. *Veterinary Anaesthesia and Analgesia* 2008, 35, 451-462.
20. Oliva V. N., Queiroz M. C. V., Albuquerque V. B., Carreira J. T., Souza T. F., Ferreira G. T., Abimussi C. J., Vides J. P.: Vitality evaluation methods for newborn puppies after cesarean section performed under general inhalation anesthesia. *Pesquisa Veterinária Brasileira* 2018, 38, 1172-1177.
21. Rodríguez-Trujillo R., Batista-Arteaga M., Iusupova K., Rosario-Medina I., Alamo-Santana D.: Comparison of propofol and alfaxalone as anesthetic drugs in bitches undergoing ovariohysterectomies (healthy bitches and with pyometra) and cesarean sections. *Animals* 2024, 14, 1343.
22. Sahinovic M. M., Struys M. M. R. F., Absalom A. R.: Clinical pharmacokinetics and pharmacodynamics of propofol. *Clin. Pharmacokinet.* 2018, 57, 1539-1558.
23. Sarotti D., Franci P., Oricco S., Rabozzi R., Lardone E.: Comparison of hemodynamic effects of propofol or alfaxalone during induction in dogs. *Front. Vet. Sci.* 2024, 11, 1442670.
24. Short C. E., Bufalari A.: Propofol anesthesia. *Vet. Clin. North Am. Small Anim. Pract.* 1999, 29, 747-778.
25. Silva L. C. G., Lucio C. F., Veiga G. A. L., Rodrigues J. A., Vannucchi C. I.: Neonatal clinical evaluation, blood gas and radiographic assessment after normal birth, vaginal dystocia or caesarean section in dogs. *Reprod. Domest. Anim.* 2009, 44, 160-163.
26. Simon L. V., Hashmi M. F., Bragg B. N.: Apgar score. 2014, [in:] *StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing.*
27. Tamura J., Ishizuka T., Fukui S., Oyama N., Kawase K., Miyoshi K., Sano T., Pasloske K., Yamashita K.: The pharmacological effects of the anesthetic alfaxalone after intramuscular administration to dogs. *J. Vet. Med. Sci.* 2015, 77, 289-296.
28. Vassalo F. G., Simões C. R. B., Sudano M. J., Prestes N. C., Lopes M. D., Chiacchio S. B., Lourenço M. L. G.: Topics in the routine assessment of newborn puppy viability. *Top Companion Anim. Med.* 2015, 30, 16-21.
29. Veronesi M. C., Panzani S., Faustini M., Rota A.: An Apgar scoring system for routine assessment of newborn puppy viability and short-term survival prognosis. *Theriogenology* 2009, 72, 401-407.
30. Vilar J. M., Batista M., Pérez R., Zagorskaia A., Jouanisson E., Díaz-Bertrana L., Rosales S.: Comparison of 3 anesthetic protocols for the elective cesarean-section in the dog: Effects on the bitch and the newborn puppies. *Anim. Reprod. Sci.* 2018, 190, 53-62.
31. Whitem T., Pasloske K. S., Heit M. C., Ranasinghe M. G.: The pharmacokinetics and pharmacodynamics of alfaxalone in cats after single and multiple intravenous administration of Alfaxan® at clinical and supraclinical doses. *Journal of Veterinary Pharmacology and Therapeutics* 2008, 31, 571-579.

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