Journal of Veterinary Research Advances
ISSN: 2582-774X

Research Article
Open access

Effects of castration on vital and some blood parameters of nigerian indigenous breed of dogs using intravenous xylazine and lidocaine/ bupivacaine spinal anaesthesia

Kalang JJ[1], Bata SI[2*], Tanko PN[3], Abdullahi SA[2] and Sambo PI[1]

[1]Department of Veterinary Medicine, Surgery and Radiology, University of Jos, Plateau state, Nigeria
[2]Department of Veterinary Science Lab. Technology. Federal College of Animal Health and Production Tech. VOM, Nigeria
[3]Department of Veterinary Microbiology and Pathology, University of Jos, Plateau state, Nigeria

Corresponding author: japhethjkalang@gmail.com

Received on: 06/01/2025 Accepted on: 11/05/2025 Published on: 19/05/2025

ABSTRACT

Aim: Purpose of the study was to evaluate the influence of lidocaine and bupivacaine spinal anaesthesia on some physiological parameters in dogs.

Method and materials: Six male dogs were used for the study. The dogs were allowed to acclimatised for two weeks with food and water been provided ad-libitum. After aseptic preparation, the dogs were divided into two groups of three dogs each. Both groups were sedated with xylazine at 2mg/kg and group one was anaesthetised using spinal anaesthesia with lidocaine and group two using bupivacaine spinal anaesthesia. The animals were draped and open castration performed. Vitals parameters and blood samples were taken and documented. Data analyzed statistically, with p-values <0.05 considered statistically significant.

Results: Lidocaine group observed approximately 89 % drop while bupivacaine recorded 92% sharp drop-in respiratory rate five minutes after xylazine and spinal anaesthesia. Furthermore, bupivacaine showed prolonged respiratory rate suppression relative to lidocaine group. The comparative analysis of the pulse rate of dogs, treated with lidocaine and bupivacaine, showed similar fluctuations. Five minutes into the surgery, the lidocaine group had a mean temperature of 38.17±3.58, while the bupivacaine group was slightly higher at 39.17±1.06. After surgery, the temperature in the lidocaine group was significantly higher compared to the bupivacaine group. Most blood parameters were statistically unaffected, however, statistical significance were seen in white blood cell count and neutrophil count.

Conclusion: It was concluded that Spinal anaesthesia with lidocaine has short effect on body temperature and less stimulation on white blood cells unlike bupivacaine. Hence, with patients with cardiovascular conditions should be given bupivacaine spinal anaesthesia with cautions.

Keywords: Bupivacaine, lidocaine, vital parameters, spinal

Cite This Article as: Kalang JJ, Bata SI, Tanko PN, Abdullahi SA and Sambo PI (2025). Effects of castration on vital and some blood parameters of nigerian indigenous breed of dogs using intravenous xylazine and lidocaine/bupivacaine spinal anaesthesia. J. Vet. Res. Adv., 07(01): 76-83.

Introduction

The demand to improve healthcare delivery has been increasing, despite good surgical techniques, skilled surgeons and improved techniques; post-surgical complications still remain the most discomforting part in patients' management (Manekk*et al*., 2022; Soliman *et al*., 2023). There is high rise in the demand and cost of health care over the past decade, exposing the constrain of resources in clinical and surgical efficiency (Soliman *et al*., 2023).

Surgical complications can be classified in grade I: as not needing any interventions, since, the patients' physiological systems are able to manage the condition. Grade II: as intervention in needed, while, grade III: is complications with permanent disability and grade IV: is where death is likely (Manekk *et al*., 2022; Soliman *et al*., 2023). Operative complications occur more often than other types of complications, and their consequences are relatively more severe. About 40% of the complications from hospitalized patients are surgery related. The incidence of the complications is 2–4.5 times more in surgery than in general medicine (Visser *et al*., 2015)

Castration (Ochidectomy; ochiectomy), the surgical removal of the testicles or neutering in male animals, is a common practice in veterinary medicine, aimed at behavior modification, improved physiological appearance, postponement of senescence, population control and selection; and prevention of reproductive-related diseases (Mejia *et al*., 2020; Hassanpour *et al*., 2024; Balen and Brady, 2025). The choice of anesthetic agents for castration procedures is crucial to ensuring optimal pain management, sedation, and surgical outcomes reducing cortisol levels (Coetzee, 2013; Gottardo *et al*., 2016; Greene and Thurmon, 1988).

Xylazine, an alpha-2 adrenergic agonist, is frequently used in sedating and premedicating subjects in veterinary anesthesia due to its effectiveness and minimal respiratory depression (Debnath and Chawla, 2023; Greene and Thurmon, 1988). However, xylazine alone may not provide sufficient analgesia for surgical procedures such as castration. Hence, is used in combination with other drugs, like the local anesthetics. The local anaesthetics are often administered in combination with the sedative to achieve balanced anesthesia and postoperative pain relief (Debnath and Chawla, 2023; Khademi *et al.,* 2020; Fang, 2019).

Lidocaine and bupivacaine are both amide-type local anesthetics, commonly used in veterinary surgery for their rapid onset, short duration of action and slow onset with prolonged duration of action respectively (Klein, and Dodam, 2023; Vullo *et al*., 2021). Lidocaine acts by blocking sodium channels, thereby inhibiting nerve conduction and providing local anesthesia, while bupivacaine exhibits similar mechanisms with a longer duration of action (Klein, and Dodam, 2023; Silva *et al*., 2023). Despite the widespread use of xylazine and local anesthetics in veterinary anesthesia, limited research has specifically evaluated their effects on vital parameters and surgical outcomes in dogs. Therefore, there is a need to investigate the impact of xylazine sedation and lidocaine/ bupivacaine anesthesia on vital parameters and on some blood parameters in dogs. Local anaesthesia during painful procedures is superior over general anaesthesia on immunity response. Local anaesthetic in combination with general anaesthesia attenuates immune suppression as well as reduces neuroendocrine response to surgery (Imani Rastabi *et al*., 2021). The use of epidural anaesthesia is cheap, with less complications and easy, providing post-operative analgesia (Garcia-Pereira 2018). Lidocaine, Characterised by rapid onset and intermediate duration (1-2 hours), it can cross the placental barrier and potentially cause cardiac alterations in the fetus (Serrano *et al*., 2024). Its toxic effects may include hypotension Bupivacaine, known for its slower onset but significantly longer-lasting anesthetic and analgesic effects, is about 3 to 4 times more potent than lidocaine exhibits higher cardiotoxicity compared to other local anesthetics. Its cardiovascular effects can include tachycardia, ventricular fibrillation, and atrioventricular block (Serrano *et al*., 2024; Khademi *et al*., 2020). The combination of local anesthetics with α2-agonists enhances and prolongs analgesia (Serrano *et al*., 2024; webster *et al*., 2024).

Materials and Methods

Six (6) male Nigerian indigenous breed of dogs between 8 – 12kg and 6 - 12 months of age were used for the study. Only male dogs with no history of previous castration or significant medical conditions were included in the study. The dogs were allowed to acclimatised for two weeks. During the period of acclimatisation at the National Veterinary Research Institute (NVRI) veterinary hospital kennel, the dogs were given food and water ad-libitum and the kennel constantly cleaned daily.

The dogs were fasted for 6 hours and 12 hours respectively from water and food prior to the procedure. The dogs were divided into two groups of three dogs each. Both groups were sedated with xylazine at 2mg/kg and group one was anaesthetised using spinal anaesthesia with lidocaine at 2mg/kg and group two was anaesthetised using spinal anaesthesia with bupivacaine at 0.5mg/kg. After aseptic preparation of the surgical site. The animals were draped and surgical castration performed, with pre-scrotal incision made and both testes excised from same incision site. The incision was closed using simple interrupted suture pattern.

Vitals parameters (heart rate, respiratory rate, and temperature) were taken prior to surgery were recorded as baseline, and at interval of 5 minutes during the procedure and after recovery from anaesthesia, one-hour after the procedure. The procedure lasted between 10-20 mins. Subsequently, blood sample was collected from the cephalic vein prior the surgery as the baseline value, at interval of 5 minutes during the procedure and after recovery from anaesthesia, one-hour after the procedure. Data were documented and analyzed statistically, with p-values <0.05 considered statistically significant.

Statistical analysis was conducted to compare vital parameters and blood parameters between the lidocaine and bupivacaine anesthesia groups. Student T-test was used to determine significant differences between groups.

Results and Discussion

The data obtained were documented as results. The drop in the mean respiratory rate within five minutes after the administration of xylazine and spinal anaesthesia in both groups as presented (Table 1), however, lidocaine group observed approximately 89 % drop while bupivacaine recorded 92% sharp drop-in respiratory rate. Furthermore, both groups showed slight fluctuation during the surgical procedure with bupivacaine showing prolonged respiratory rate suppression relative to lidocaine group. Lowest values were recorded at 20 minutes for the lidocaine group and at 10 minutes for the bupivacaine group. Five minutes into the surgery, the lidocaine group had a mean respiratory rate of 17.33±4.93, while the bupivacaine group had a rate of 16.33±3.21, showing no significant difference. By 10 minutes, the rates were closely matched at 15.33±1.53 for the lidocaine group and 15.00±3.00 for the bupivacaine group. The table also showed, that after 20 minutes, the lidocaine group had a respiratory rate of 14.67±0.58, while the bupivacaine group had a slightly higher respiratory rate of 16.00±2.65. After surgery, the respiratory rate increased to near initial value 20.67±8.08 in the lidocaine group and 18.00±3.46 in the bupivacaine group.

It was showed the comparative analysis of the pulse rate of dogs, treated with lidocaine and bupivacaine (Table 2). The table illustrates that the mean pulse rate before surgery was higher in the lidocaine group (75.33±15.01) compared to the bupivacaine group (60.33±8.02). Five minutes into the commencement of the surgery, the pulse rate for the lidocaine group was 53.33±2.08, while for the bupivacaine group, was 52.33±10.79. The table further showed that, at 10 minutes into the surgery, the pulse rates were 52.00±3.61 for the lidocaine group and 46.67±4.16 for the bupivacaine group. By 20 minutes, the pulse rates slightly increased in the lidocaine group to 53.00±6.25 and in the bupivacaine group to 48.00±7.00. After surgery, the pulse rates were closely aligned, with the lidocaine group at 58.67±20.23 and the bupivacaine group at 61.33±1.15. The table demonstrates that, there were no significant differences in pulse rates between the two treatment groups throughout the surgical procedure.

It was observed the comparative analysis of the body temperature of dogs treated with lidocaine and bupivacaine (Table 3). The table revealed that, before surgery the mean temperature was 37.35±5.06 for the lidocaine group and 38.60±0.52 for the bupivacaine group. At 5 minutes into the surgery, the lidocaine group had a mean temperature of 38.17±3.58, while the bupivacaine group was slightly higher at 39.17±1.06. The table also indicates that 10 minutes into the surgery the temperatures were 37.27±1.19 and 39.07±0.89 for the lidocaine and bupivacaine groups, respectively. By 20 minutes, the temperature for the lidocaine group was 38.03±0.12, while it was 38.63±1.04 for the bupivacaine group. Notably, after surgery, the temperature in the lidocaine group was significantly higher at 38.63±0.50 compared to the bupivacaine group at 35.80±0.00. The table highlights that there was a significant difference in the body temperature of dogs between the two treatments after surgery, with the lidocaine group maintaining a higher temperature.

Table 1: Peri-castration analysis of respiratory rate in Nigerian Indigenous Breed of Dogs using lidocaine/ bupivacaine spinal anaesthesia and intravenous xylazine

	Drugs (Mean±SD)		
Time interval	Lidocaine	Bupivacaine	P-value
Before surgery	22.33±6.43	25.00±4.36	0.729
5 mins	17.33±4.93	16.33±3.21	0.783
10 mins	15.33±1.53	15.00±3.00	0.872
15 mins	17.00±2.65	17.33±2.52	0.882
20 mins	14.67±0.58	16.00±2.65	0.442
After surgery	20.67±8.08	18.00±3.46	0.627

Table 2: Peri-castration analysis of pulse rate in Nigerian Indigenous Breed of Dogs using lidocaine/ bupivacaine spinal anaesthesia and intravenous xylazine

	Drugs (Mean±SD)		
Time interval	Lidocaine	Bupivacaine	P-value
Before surgery	75.33±15.01	60.33±8.02	0.202
5 mins	53.33±2.08	52.33±10.79	0.882
10 mins	52.00±3.61	46.67±4.16	0.169
15 mins	49.67±2.89	44.67±5.69	0.246
20 mins	53.00±6.25	48.00±7.00	0.408
After surgery	58.67±20.23	61.33±1.15	0.831

Table 3: Peri-castration analysis of temperature in Nigerian Indigenous Breed of Dogs using lidocaine/ bupivacaine spinal anaesthesia and intravenous xylazine

	Drugs (Mean±SD)		
Time interval	Lidocaine	Bupivacaine	P-value
Before surgery	37.73±5.06	38.60±0.52	0.385
5 mins	38.17±3.58	39.17±1.06	0.201
10 mins	37.27±1.19	39.07±0.89	0.105
15 mins	37.30±1.21	39.00±0.95	0.130
20 mins	38.03±0.12	38.63±1.04	0.377
After surgery	38.63±0.50	35.80±0.00	0.001

It was showed the blood parameters that were evaluated in the work (Table 4). The blood parameters were mostly seen to be statistically unaffected, however, statistically significant results were seen in white blood cell count and neutrophil count.

It was presented a comparative analysis of the physiological responses of dogs treated with lidocaine and bupivacaine peri-surgically. The age or weight of a patient does not predict systemic serum concentration following calculated doses in milligrams per age (years) or milligrams per kilogram (Becker and Reed, 2012). The data reveal that the respiratory rates of dogs in both treatment groups were closely aligned at all measured time points. Specifically, during surgery, respiratory rates sharply decreased in both groups 5 min after the administration of the anaesthetic agents to low normal and it fluctuates all through the procedure, with no significant differences between the treated groups. The lidocaine-xylazine treated had the respiratory rate retuned to initial value before surgery one-hour post-surgery, however, the bupivacaine-xylazine treated had the respiratory rate at low normal one-hour post-surgery, though the differences were not statistically significant. The maintenance of the respiratory rate within normal range in the surgical procedure was in line with the documented report of the influence of local anaesthetics on physiological parameters Debnath and Chawla (2023); Olaifa and Oluranti (2018) reported that local anaesthetics has connection with the stability of the autonomic, cardiovascular, respiratory and thermoregulatory systems. However, the prolong suppression of the respiratory rate in bupivacaine- xylazine treated could be as prolong effects of bupivacaine as stated by Klein and Dodam, (2023). The pulse rate steadily decreases after treatment and starts to increase twenty minutes into the procedure this could be as a result of the suppressive effects of the xylazine on the heart as also reported by Debnath and Chawla, (2023); Greene and Thurmon, (1988), who documented cardiovascular suppression with the use of xylazine. It was also noticed the lidocaine-xylazine group consistently maintaining a slightly higher pulse rate which implies relatively less cardiovascular suppression compared to the bupivacaine-xylazine group. Report by Hall *et al.* (2001) found that bupivacaine exhibits greater potential for direct cardiac toxicity than other local anaesthetic agents (Becker and Reed, 2012). The temperature of the treated groups were slightly higher than the pre-surgical values five minutes into the surgery and subsequently drops through the surgery. The temperature in the lidocaine-xylazine treated group was noticed to have returned to normal value one-hour after the surgery, however, the temperature remains sub-normal significantly in the bupivacaine-xylazine treated groups one-hour after surgery suggests a potential difference in how these drugs affect thermoregulation center post-operatively.

Table 4: Peri-castration comparative analysis of haematology in xylazine sedated dogs treated with spinal lidocaine/ bupivacaine infiltration

TIME	LIDOVACAINE	BUPIVACAINE	P-Value
PCV			
PCV Before	32.67 ± 9.07	38.33 ± 4.04	0.913
5mins	32.00 ± 3.61	26.33 ± 10.21	0.416
10mins	20.00 ± 14.73	25.67 ± 8.14	0.591
15mins	36.33 ± 3.21	35.67 ± 16.79	0.923
20mins	33.67 ±3.06	34.33 ± 3.31	0.863
PCV After	31.33 ± 6.66	33.67 ± 12.50	0.790
HB			
HB Before	9.32 ± 2.62	9.22 ± 0.96	0.952
5mins	9.23 ± 1.16	9.22 ± 0.96	0.952
10mins	8.42 ± 0.71	7.48 ± 2.68	0.357
15mins	10.22 ± 0.80	9.65 ± 2.59	0.736
20mins	9.56 ± 0.92	9.44 ± 1.50	0.917
HB After	8.80 ± 1.98	9.25 ± 3.32	0.851
RBC			
RBC Before	4.92 ± 1.68	5.67 ± 1.16	0.584
5mins	4.33 ± 0.23[a]	1.90 ± 1.31[b]	0.034
10mins	4.87 ± o.74[a]	2.07 ± 1.36[b]	0.035
15mins	4.90 ± 0.00	6.03 ± 1.88	0.356
20mins	4.60 ± 0.81	6.67 ± 1.80	0.124
RBC After	4.93 ± 0.81	5.93 ± 2.60	0.559
WBC			
WBC Before	4.90 ± 0.56	5.60 ± 0.56	0.198
5mins	4.63 ± 0.57	5.27 ± 0.85	0.344
10mins	5.50 ± 0.26[a]	4.67 ± 0.45[b]	0.037
15mins	5.47 ± 0.67	5.67 ± 0.93	0.977
20mins	4.67 ± 0.40[b]	6.07 ± 0.15[a]	0.005
WBC After	4.90 ± 1.00	6.67 ± 2.25	0.282
L			
L Before	37.00 ± 3.00[b]	71.07 ± 14.29[a]	0.015
5mins	53.00 ± 24.56	61.67 ± 2.89	0.577
10mins	51.62 ± 24.79	82.33 ± 9.29	0.115
15mins	43.33 ± 10.64[b]	75.00 ± 11.53[a]	0.025
20mins	46.00 ± 26.00	65.33 ± 12.34	0.309
L After	30.00 ± 8.72	70.33 ± 22.37	0.044
N			
N Before	61.67 ± 1.53	27.33 ± 14.24[b]	0.016
5mins	47.00 ± 24.56	38.33 ± 2.84	0.577
10mins	52.00 ± 9.64	17.67 ± 9.29[b]	0.011
15mins	34.83 ± 20.62	51.33 ± 27.32	0.164
20mins	50.33 ± 27.30	23.00 ± 9.17	0.293
N After	66.00 ± 7.21	21.33 ± 10.02[b]	0.003

This could be as a result of the longer effects of bupivacaine on the body temperature of the animal which could be as a result of its longer effects on the hypothalamus. The hypothalamus is known to regulate body temperature as reported by Goel *et al*. (2024). Studies by Dugdale *et al.,* (2020) Grimm *et al*. (2017) had suggested that lidocaine induce mild hyperthermia postoperatively, aligning with the higher post-surgery body temperatures observed in the lidocaine group earlier than that in the bupivacaine. These results underscore the importance of choosing the appropriate anesthetic protocol based on the specific physiological responses required during and after surgical procedures.

The packed cell volume gradually droped to minimal in both experimental groups at 10 min into the procedure before it starts rising to initial percentage one-hour after surgery in the lidocaine-xylazine treated group while it lasts more than one-hour in the bupivacaine-xylazine treated group. It was indicated relatively longer cardiovascular system suppression by bupivacaine-xylazine treated group, it could be as a result of documented longer therapeutic effects of bupivacaine Klein and Dodam, (2023). Bupivacaine exhibits 95% protein binding compared to lidocaine less than 55%, and this is attributed to the difference in their duration of neural blockade, bupivacaine has more affinity for the inactive and resting sodium channel configurations and its dissociation from these channels is additionally gradual. Lidocaine shortened its own duration of neural blockage by dilating local vasculature, whereas bupivacaine does not, furthermore, lidocaine exhibit poor nerve block efficacy as documented by Becker and Reed, (2012). Haemoglobin concentration was seen to steadily reduce in concentration to the minimal, 10 mins into the procedure and steadily returns to presurgical concentration one-hour after the procedure. While the red blood cell count were observed to reduce to minimal level, 5 mins into the procedure. It signified similar influence of lidocaine-xylazine and bupivacaine-xylazine effect on haemoglobin concentration and red blood cell count. However, significant difference was observed in white blood cell (WBC) count, 20 mins into the procedure with drop in WBC count of the group treated with lidocaine-xylazine. This suggested the least chances of immunological stimulation by lidocaine-xylazine treated relative to bupivacaine treated group. The lymphocytes were relatively stable in bupivacaine-xylazine treated group but slightly fluctuates in the lidocaine-xylazine group. The neutrophil count was significant one-hour after the procedure with drop in the bupivacaine-xylazine group. Surgery is accompanied with levels of immunosuppression. The immune disturbances can speeds-up the development of the remained cancer cells after debunking. Surgeries were associated with the trauma-induced stress, hence, activates the hypothalamic-pituitary–adrenal axis and the secretion of catecholamines and glucocorticoids, these have direct immunosuppressive effects. At cellular level the activities of the immune system can be impaired by most anaesthetic agents. Anaesthesia can modulate surgical stress and affect the immune response as reported by Imani Rastabi *et al*., (2021).

Conclusion

It was concluded that the respiratory rate in dogs treated with lidocaine and bupivacaine during surgery remains unaffected and statistically insignificant, reflecting that both anesthetics maintain stable respiratory function. The pulse rate, while higher in the lidocaine group and lower in the bupivacaine group, also did not show statistical significant difference, however, bupivacaine showed relatively prolong cardiovascular suppression, implying caution been required in the use in patients with low blood pressure or with cardiovascular disease condition during surgery. However, these findings on body temperature provide more nuanced insights. While temperature fluctuations were not significantly different during surgery, the patterns observed—where the lidocaine group generally maintained a lower body temperature (low normal range) and the bupivacaine group maintained a higher body temperature (high normal range) are noteworthy. This trend reversed during recovery, with the lidocaine group showing a significant increase in body temperature compared to the bupivacaine group, which experienced a marked decrease. This significant difference in postoperative thermoregulation highlights a key consideration for clinicians in selecting anesthetics, as it influences recovery outcomes and the need for temperature management post-surgery.

Reference

Becker DE and Reed KL (2012). Local anesthetics: review of pharmacological considerations. Anesthesia progress, 59(2): 90–103. https://doi.org/10.2344/0003-3006-59.2.90

Belen J and Brady CM (2025). Benefits of castration in male dogs. Animal Sciences, Purdue University, AS-562-W. https://www.extension.purdue.edu› as-562-w. Retrieved 17/04/2025

Coetzee JF (2013). Assessment and Management of Pain Associated with Castration in Cattle, Veterinary Clinics of North America: Food Animal Practice, 29(1): 75-101. https://doi.org/10.1016/j.cvfa.2012.11.002.

Debnath R and Chawla P (2023). Xylazine addiction turning humans to zombies: Fact or myth?. Health Sciences Review, 9(2023): 100132. https://doi.org/10.1016/j.hsr.2023.100132.

Dugdale A, Beaumont G, Bradbrook C and Gurney M (2020). Veterinary anaesthesia: Principles to practice. Published by John Wiley and sons, pp 191-204.

Fang H, Li H, Yang M, Zhang F, Liao R, Wang R, Wang Q, Zhang P and Zhang J (2019). Effect of ketamine combined with lidocaine in pediatric anesthesia. Journal of clinical laboratory analysis, 15(34): e23115. 10.1002/jcla.23115.

Garcia-Pereira F (2018). Epidural anesthesia and analgesia in small animal practice: An update. The Veterinary Journal, 242(2018): 24–32. https://doi.org/10.1016/j.tvjl.2018.09.007

Goel M, Mittal A, Jain VR, Bharadwaj A, Modi S, Ahuja G, Jain A and Kumar K (2024). Integrative functions of the hypothalamus: linking cognition, emotion and physiology for well-being and adaptability. Annals of Neuroscience, 1(1): 1-15. https://doi.org/10.1177/0972753124125549

Gottardo F, Scollo A, Contiero B, Ravagnani A, Tavella G, Bernardini D, De Benedictis GM and Edwards SA (2016). Pain alleviation during castration of piglets: a comparative study of different farm options. Journal of Animal Science, 94(12): 5077–5088. https://doi.org/10.2527/jas.2016-0843

Greene SA and Thurmon JC (1988). Xylazine – a review of its pharmacology and use in veterinary medicine. Journal of Veterinary Pharmacology and therapeutics, 11(4): 295–313. https://doi.org/10.1111/j.1365-2885.1988.tb00189.x

Grimm K, Lamont L, Tranquilli WJ, Greene SA and Robertson S (2017). Veterinary anesthesia and analgesia, The 5th edition of Lumb and Jones. Published by Wiley-Blackwell. pp 332-355.

Hall LW, Clarke KW and Trim CM (2001). Textbook of veterinary anaesthesiology, 10th edition, published by W.B. Saunders. Pp. 203-300

Hassanpour H, Javdani M, Changaniyan-Khorasgani Z, Rezazadeh E, Jelali R and Mojtahed M (2024). Is castration leading to biological aging in dogs? Assessment of lipid peroxidation, inflammation, telomere length, mitochondrial DNA copy number, and expression of telomerase and age-related genes. BMC Veterinary Research, 20(1): 485. https://doi.org/10.1186/s12917-024-04337-9

Imani Rastabi H, Khosravi M, Avizeh R and Moslemi M (2021). Evaluation of the effect of lidocaine epidural injection on immunological indices in dogs under total intravenous anesthesia submitted to ovariohysterectomy. Public library of Science one, 16(6): e0253731. https://doi.org/10.1371/journal.pone.0253731.

Khademi S, Lankarani HM, Kashani S, Alavian SM, Nazari R and Khoshdel AR (2020). Effectiveness of local infiltration analgesia with lidocaine with epinephrine versus bupivacaine in reducing pain after perineal prostatic biopsy: a randomized clinical trial. Anesthesiology and Pain Medicine, 10(3).

Klein SE and Dodam JR (2023). Comparison of lidocaine and lidocaine-xylazine for distal paravertebral anesthesia in dairy cattle. Journal of American Veterinary Medical Association, 262(2): 241-245. https://doi.org/10.2460/javma.23.07.0373

Manekk RS, Gharde P, Gattani R and Lamture Y (2022). Surgical complications and its grading: A literature review. Cureus 14(5): e24963. https://doi.org /10.7759/cureus24963

Mejia S, Duncan C, Iodence A, Monnet E, Wheeler R and Duerr F (2020). Evaluation of completeness of resection of the glandular portion of the uterus with hysterectomy in dogs – A pilot study. Animal Production Science. 219(2): 106527. https://doi.org/10.1016/j.anireprosci.2020.106527

Oberbauer AM, Belanger JM and Famula TR (2019). A Review of the Impact of Neuter Status on Expression of Inherited Conditions in Dogs. Frontier Vet. Sci. 6: 397. https://doi.org/10.3389/fvets.2019.00397

Olaifa AK and Oluranti OI (2018). The use of epidural anaesthesia over general anaesthesia in ruminants. Concepts of Dairy and Veterinary Sciences, 1(3): 68-71. https://doi.org/10.32474/CDVS.2018.01.000111

Serrano BP, Fukushima AR, Muñoz JWP, Nascimento FLD, Conceição VDF, Almeida GR, Almeida TR, Morais CLDM and Futema F (2024). Advancements in epidural anesthesia for small animals: a comprehensive literature review. Journal of Dairy Veterinary and Animal Research. 13(1): 1–10.

Silva A, Mourão J and Vale N (2023). A review of the lidocaine in the perioperative period. Journal of Personalised Medicine, 13(12): 1699. https://doi.org/10.3390/jpm13121699

Soliman C, Sathianathen NJ, Thomas BC, Giannarini G, Lawrentschuk N, Wuethrich PY, Dundee P, Nair R and Furrer MA (2023). A Systematic Review of Intra- and Postoperative Complication Reporting and

Grading in Urological Surgery: Understanding the Pitfalls and a Path Forward. EurUrol Oncol. 2023 Aug; 6(4): 378-389. https://doi.org /10.1016/j.euo.2023.01.002.

Visser A, Geboers B, Gouma DJ, Goslings JC and Ubbink DT (2015). Predictors of surgical complications: A systematic review. Surgery, 158(1): 58-65.

Vullo C, Tambella AM, Meligrana M and Catone G (2021). Analgesic and sedative effects of epidural lidocaine-xylazine in elective bilateral laparoscopic ovariectomy in standing mule Mares. Animals, 11(8): 2419. https://doi.org/10.3390/ani11082419

Webster A, Pezzanite L, Hendrickson D and Griffenhagen G (2024). Review of intra-articular local anaesthetic administration in horses: Clinical indications, cytotoxicity, and outcomes. Equine veterinary journal, 56: 870-883.

******