# Use of a bipolar vessel sealing device in canine orchiectomy

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## ARTICLE INFO

**Article History**
Received : 23.03.2022
Accepted : 10.06.2022
DOI: 10.33988/auvfd.1092062

**Keywords**
Bipolar vessel sealing
Canine
Orchiectomy
Postoperative complication
Postoperative pain

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**How to cite this article:** Yaman C, Kanca H (2023): Use of a bipolar vessel sealing device in canine orchiectomy. Ankara Univ Vet Fak Derg, 70 (4), 375-382. DOI: 10.33988/auvfd.1092062.

## ABSTRACT

Bipolar vessel sealing (BVS) devices are being used increasingly in veterinary medicine. The objective was to determine whether the use of a BVS device in prescrotal open orchiectomy of dogs reduced surgical time, postoperative pain and surgical site complications compared to ligation with suture. Fifty medium to large breed dogs admitted for elective castration were randomly assigned to either the ligation or BVS groups. Duration of surgery, pain score at postoperative 15 minutes, 1, 2, and 24 hours, and surgical site swelling and bruising scores at 24 hours were compared. Duration of surgery was shorter (P<0.001) in the BSV group (median 8.30; range 7.03 to 10.17 minutes) than the ligation group (median 10.18; range 7.47 to 12.33 minutes). There was a significant effect of age (r=0.458, P=0.021) and body weight (r=0.432, P=0.031) of the animal on the duration of surgery in the BVS group. Lower pain scores were observed in the BVS group at postoperative 15 minutes (P=0.001) and 1 hour (P=0.045). Pain scores were not different between groups at 2 hours and 24 hours (P>0.05). The surgical site swelling score was lower (P=0.034) in the BVS group (0.24 ± 0.09) compared to the ligation group (0.72 ± 0.17). A lower bruising score (P=0.015) was observed in the BVS group (0.44 ± 0.13) than in the ligation group (1.16 ± 0.22). The use of BVS method was associated with significantly shorter surgery times and lower postoperative pain and surgical site complications than traditional ligation technique in canine open orchiectomy.

## Introduction

Canine castration is a common surgical procedure in small animal practice. Surgical castration provides contraception (38), decreases behaviour problems (26) and helps prevent and treat reproductive pathologies (3, 7). Many surgical castration techniques have been described in the dog. The open technique by using a prescrotal incision is commonly preferred in adult dogs, for it allows more reliable ligations by direct placement of the ligatures around the vascular pedicle (18).

Complications of canine castration include postoperative pain, scrotal swelling, haemorrhage, subcutaneous bruising, self-trauma to the surgical site and infection. Haemorrhage may be serious and may result in scrotal hematoma or intraabdominal haemorrhage (18). In the dog, surgical site swelling and bruising are frequently observed after open castration (4). The incidence of surgical site complications for prescrotal castration is high in adult dogs (22, 30) and complication rates of up to 61% have been reported (13).

Recent advances in minimal invasive techniques in surgery leading to reduced morbidity, less pain and faster patient recovery are driving forces behind efforts in veterinary practice to make procedures less invasive (28). Small animal practitioners may benefit from reducing the duration of common surgical procedures tremendously. Suture ligation, the standard haemostatic technique during open surgical castration of dogs, can be cumbersome and technically challenging (17). Recently, the use of bipolar electrosurgical forceps for haemostasis for canine castration was described. However, the use of electrocautery forceps did not reduce surgical time compared to ligation with sutures (37). Vessel-sealing devices offer a valuable alternative to mechanical ligation techniques to provide reliable haemostasis due to the short time needed and potential reduction in intraoperative blood loss, surgical time and postoperative complications (24).

Electrothermal bipolar vessel sealing (BVS) technology depending on tissue response generators is one of the most recent advancements in electrosurgery (11). The efficacy and safety of BVS devices in many canine surgical procedures have been described and these devices are being used increasingly in veterinary surgery, especially during laparoscopic procedures (39, 40). Bipolar vessel sealing devices fuse vessels and form reliable seals by targeted, feedback-controlled delivery of electrical current and mechanical pressure (19). Denaturation of collagen and elastin combined with the mechanical pressure leads to coagulum formation (16). In comparison with monopolar coagulation that reliably seals small vessels with a diameter of 1-3 mm, BVS devices are able to provide hemostasis of vessels up to 7 mm in diameter depending on the instrument chosen (34).

The objective of this study was to compare bipolar vessel sealing method with routine ligation in prescrotal bilateral open orchiectomy of dogs in terms of surgical time, surgical site complications and postoperative pain scores.

## Materials and Methods

Fifty medium and large-breed dogs admitted for elective castration were included. The health status of dogs was determined based on medical history, physical examination and complete blood count performed on the day of admission. Signed informed owner consent was obtained before random assignment of dogs to either ligation or BVS groups. All dogs were in generally good health. Dogs <6 months and >5 years of age and those requiring any additional surgery or having any evidence of scrotal or testicular disease were not included in the study. The study protocol was reviewed and approved (Approval no: 2017-4-30) by the Local Ethics Committee on Animal Experiments, Ankara University, Türkiye.

***Preoperative evaluation:*** Food and water were withheld for approximately 6 hours before surgery. One hour before surgery, the animals received 0.2 mg/kg meloxicam intra-muscularly (im) as a pre-emptive analgesic and 15 mg/kg long-acting amoxicillin trihydrate im was used for prophylaxis. Dogs were premedicated with 0.01 mg/kg medetomidine im. Intravenous (iv) catheters were placed into a cephalic vein in all animals before induction of anaesthesia with propofol 6 mg/kg iv. The dogs were intubated and isoflurane in oxygen at a flow rate of 2% was used for anaesthesia maintenance. Electrocardiogram, heart rate, respiration rate and blood oxygen saturation were continuously monitored. Lactated Ringer’s solution was administered iv at a rate of 5 mL/kg/hour during surgery.

***Surgical technique:*** After the achievement of the surgical plane of anaesthesia, bilateral orchiectomy was performed using the standard open technique (15). Briefly, a prescrotal skin incision sufficient in length to allow exteriorization of the testicle was made with a scalpel blade. The testis was pushed cranially and the vaginal tunic was exposed and incised before exteriorization of the testicle. The tunics were separated from the remainder of the spermatic cord. In the ligation group, transfixation sutures were placed in the vaginal tunic and the spermatic cord separately by using 0.2-0 or 3-0 Polyglactin 910. The spermatic cord and tunic were transected distal to the ligatures and replaced into the incision after final bleeding control.

A BVS device (LigaSure™ 5 mm blunt tip 37 cm sealer) was used both for sealing and dissection of the vaginal tunic and the spermatic cord in the BVS group. Valleylab™ LS10 Generator energy platform was used as the energy source. The generator includes a feedback-controlled response system for automatic cessation of energy delivery once the seal cycle is complete. Standard settings according to the company instructions were maintained, with the instrument set at an intermediate power.

The procedure was then repeated for the other testis in both groups. The skin incision was closed with a 2-0 or 3-0 absorbable synthetic suture material (Poly lactic-co-glycolic acid, PLGA) in a simple interrupted subcutaneous and intra-dermal pattern. Duration of surgery, beginning with skin incision and ending with placement of the final skin suture, was recorded for each case. An aerosol antibiotic spray containing oxytetracycline hydrochloride was applied on the surgical site. The first author, experienced in canine castration, who had undergone basic 2-hour training in BVS performed all surgeries.

***Postoperative care and follow up:*** After the surgical procedure, dogs received 0.01 mg/kg atipamezole im and were monitored until fully recovered from anaesthesia. An Elizabethan collar was placed and patients were followed up at least 24 hours. Postoperative pain and complications were evaluated by a veterinarian blinded to the treatment. The severity of postoperative pain was evaluated at 15 minutes, 1, 2 and 24 hours post-surgery using a pain score evaluation form (Table 1) as described (35). Ketoprofen 2 mg/kg im was planned to be administered as rescue analgesia in patients with pain scores greater than 4 at any time point. Swelling and bruising of the surgical sites were scored at 24 h using a previously described (35) scale (Table 2). Any surgical or anaesthesia related complication developed during or after surgery in the follow-up period was recorded as major complications requiring intervention or minor complications requiring observation only. The study protocol was terminated after a follow-up period of 24 h and the dogs were discharged from the hospital. The owners were asked to examine the surgical site and general status of their dogs and to represent them in case of suspected complications. Routine follow-up assessments were made 7 to 10 days after surgery.

***Statistical analysis:*** All statistical comparisons were performed using SPSS (SPSS Statistics Version 23; IBM Corporation). Assumptions for homogeneity of variances and normality of the data were tested by Levene’s test and Shapiro-Wilk’s test, respectively. Student t-test was used in the comparison of normally distributed continuous variables between the study groups. Continuous variables that were not normally distributed were compared between groups by the Mann-Whitney U test.

The Friedman test was used to analyse the difference between times for pain scores and a Wilcoxon matched pairs test with Bonferroni correction was used for pairwise comparisons. Correlations between surgery duration, age, body weight, the severity of surgical site swelling and severity of surgical site bruising were assessed using Spearman's correlation coefficient. Results were presented as mean ± SEM when normally distributed and as median (range) otherwise. The significance level was set at $P<0.05$.

**Table 1.** Pain score evaluation form used (35).

| Criteria | Score | Description |
|---|---|---|
| Comfort | 0 | Dog asleep or calm |
| | 1 | Mild-moderate agitation, awake, interested in surroundings |
| | 2 | Extremely agitated |
| Movement | 0 | No movement |
| | 1 | Frequent positional changes per min |
| | 2 | Continuous positional changes per min |
| Appearance | 0 | Eye normal or partially closed, ears flattened or normal in position |
| | 1 | Moderate changes, eyes glazed, unthrifty appearance |
| | 2 | Severe changes: eyes pale, pupils enlarged, guarding, legs in abnormal position or other abnormal facial expressions |
| Vocalization | 0 | No vocalization |
| | 1 | Crying, responds to calm voice and stroking |
| | 2 | Crying, does not respond to calm voice and stroking |
| Heart rate | 0 | <10% greater than preoperative value |
| | 1 | 10-25% greater than preoperative value |
| | 2 | 25% or more greater than preoperative value |
| Respiratory rate | 0 | <10% greater than preoperative value |
| | 1 | 10-25% greater than preoperative value |
| | 2 | 25% or more greater than preoperative value |
| Total (0–12) | | |

**Table 2.** Criteria used for surgical site evaluation at postoperative 24 hours (35).

| Swelling evaluation | Score | Bruising evaluation | Score |
|---|---|---|---|
| No swelling | 0 | No bruising | 0 |
| Mild swelling | 1 | Mild bruising | 1 |
| Moderate swelling | 2 | Moderate bruising | 2 |
| Marked swelling | 3 | Marked bruising | 3 |
| **Swelling score description** | | | |
| 0 | No visible evidence of swelling noted | | |
| 1 | Swelling minor, raised less than 2-3 mm and extending less than 2-3 mm | | |
| 2 | Swelling obvious but not significantly irritated. Extending between 3 and 6 mm laterally or raised | | |
| 3 | Swelling clearly visible. Over 6 mm in width or height, obviously irritated | | |
| **Bruising score description** | | | |
| 0 | No visible evidence bruising | | |
| 1 | Minor bruising, color minimally changed, bruise extends less than 3 mm | | |
| 2 | More significant erythema or color change. Bruise obvious but between 3 and 6 mm in distance from incision | | |
| 3 | Bruise is obvious, over 6 mm in size darker in color, more pronounced erythema | | |

DOI: 10.33988/auvfd.1092062

## Results

The average age and body weight of the dogs and total surgical time in study groups are shown in Table 3. There were no significant differences between the age (P=0.168) and the body weight (P=0.678) of dogs in study groups. The median ages of the dogs were 9 months (range 6 months to 54 months) and 10 months (range 6 months to 36 months) in ligation and BVS groups, respectively. The median body weight of the ligation group dogs was 21.80 ± 1.34 kg and it was 22.72 ± 1.75 kg in the BVS group.

The median duration of surgery was 10.18 (7.47-12.33) and 8.30 (7.03-10.17) minutes in the ligation group and the BVS group, respectively (P<0.001). There was a significant effect of age (r=0.458, P=0.021) and body weight (r=0.432, P=0.031) of the animal on the duration of surgery in the BVS group.

Postoperative pain scores at 15 minutes, 1, 2 and 24 hours in ligation and BVS groups are given in Table 4. Pain score > 4 necessitating rescue analgesia was not observed at any time point. Pain scores were significantly reduced by time in both groups (P<0.001). Lower mean pain scores were observed in the BVS group at postoperative 15 min (P=0.001) and 1 h (P=0.045). Mean pain scores in ligation and BVS groups were not different at 2 and 24 hours (P>0.05).

None of the dogs had major surgical or anaesthetic complications. Surgical site swelling and bruising scores are shown in Table 5. The mean swelling score was lower in the BVS group compared to the ligation group (P=0.034). Nineteen dogs had no swelling and 6 dogs had minor swelling in the BVS group. No swelling was observed in 13 dogs in the ligation group. However, 6 dogs had minor and 6 dogs had moderate swelling.

**Table 3.** The average age, body weight of dogs and total surgical time in ligation and bipolar vessel sealing (BVS) groups.

| Parameter | Group (n=25) | Mean ± SEM | Median (range) | P |
|---|---|---|---|---|
| Surgical time(minutes) | Ligation | 9.81 ± 1.23[a] | 10.18 (7.47-12.33) | <0.001 |
| | BVS | 8.50 ± 0.86[b] | 8.30 (7.03-10.17) | |
| Age (months) | Ligation | 14.20 ± 2.78 | 9 (6-54) | 0.168 |
| | Vessel sealing | 13.92 ± 1.56 | 10 (6-36) | |
| Body Weight(kg) | Ligation | 21.80 ± 1.34 | 20 (13-38) | 0.678 |
| | Vessel sealing | 22.72 ± 1.75 | 24 (8-40) | |

BSV, Bipolar vessel sealing; Kg, kilograms; SEM, standard error of mean.
[a,b] Within a column, means for same parameter without a common superscript differ (P<0.001).

**Table 4.** Postoperative pain scores in ligation and bipolar vessel sealing groups at different time points.

| Postoperativepain score | Ligation group (n=25) | | Bipolar vessel sealing group(n=25) | | P |
|---|---|---|---|---|---|
| Time point | Mean ± SEM | Median (range) | Mean ± SEM | Median (range) | |
| 15 minutes | 2.80 ± 0.15[c] | 3 (2-4) | 2.04 ± 0.14[c] | 2 (1-3) | 0.001 |
| 1 hour | 1.52 ± 0.17[b] | 2 (0-3) | 1.12 ± 0.12[b] | 1 (0-2) | 0.045 |
| 2 hours | 0.72 ± 0.15[ab] | 1 (0-2) | 0.64 ± 0.13[ab] | 1 (0-2) | 0.765 |
| 24 hours | 0.28 ± 0.14[a] | 0 (0-2) | 0.40 ± 0.10[a] | 0 (0-1) | 0.138 |
| P | <0.001 | | <0.001 | | |

SEM, Standard error of mean.
[a,b,c] Within a column, means without a common superscript differ (P<0.05).

**Table 5.** Surgical site swelling and bruising scores in ligation and bipolar vessel sealing groups at postoperative 24 hours.

| Parameter | Group (n=25) | Mean ± SEM | Median (range) | P |
|---|---|---|---|---|
| Surgical site swelling score | Ligation | 0.72 ± 0.17 | 0 (0-2) | 0.034 |
| | Bipolar vessel sealing | 0.24 ± 0.09 | 0 (0-1) | |
| Surgical site bruising score | Ligation | 1.16 ± 0.22 | 1 (0-3) | 0.015 |
| | Bipolar vessel sealing | 0.44 ± 0.09 | 0 (0-2) | |

SEM, Standard error of mean.

DOI: 10.33988/auvfd.1092062

The surgical site bruising score at 24 h was significantly lower (P=0.015) in the BVS group (0.44 ± 0.13) compared to the ligation group (1.16 ± 0.22). There was no bruising in nine dogs in the ligation group. Seven, five and four dogs had mild, moderate and marked bruising on the surgical site in the ligation group, respectively. No marked bruising was observed in the BVS group. Sixteen dogs had no bruising on the surgical site. However, mild bruising was observed in seven dogs and moderate bruising was observed in two dogs. No interventions were made for surgical site complications, swelling and bruising resolved spontaneously in a couple of days.

Surgical site bruising was associated with surgical site swelling in ligation (r=0.769, P=0.001) and BVS group (r=0.783, P=0.001). Surgical site bruising and swelling were not associated with the duration of surgery, age or bodyweight of the animal in either group (P>0.05).

## Discussion and Conclusion

The use of a BVS method in the current study enabled open prescrotal orchiectomy to be completed in a shorter time. This reduction in surgical time is due to the time saved by eliminating the need for tedious knot-tying. With the use of bipolar haemostasis devices, ligation techniques have become less preferred. In this way, bleeding control can be achieved more easily, especially in areas that are difficult to access, which shortens the operation time (28). Being one of the most common surgical procedures in veterinary practice, it is important to shorten the surgical time for orchiectomy, especially in intensive sterilization programs. The advantages of vessel-sealing devices in canine ovariectomy have been shown previously (8, 27), and the surgical time was reduced compared with ligation with suture (32). To the best of the authors' knowledge, this is the first study on the use of vessel sealing devices in canine orchiectomy.

The mean duration of surgery in both study groups is comparable to (31, 37) or shorter (21, 36) than previous reports. It is theoretically suggested that closed orchiectomy is easier and can be completed in a shorter time (4). However, in a study comparing open and closed orchiectomy, the mean surgical time was reported as 21.9 ± 11.5 min and 20.0 ± 9.5 min for open and closed orchiectomy, respectively (13). Although the open technique was used in the current study, relatively short surgical times were observed. This result has been associated with surgeon experience. Surgical time in canine orchiectomy strongly depends on surgeon experience (33), and repetition of the procedure helps improve surgical skills as measured by surgery time (10). Interestingly, increasing body weight and age were associated with a longer duration of surgery in the BVS group, but not in the ligation group. The change in relative anatomic size and tissue composition associated with body weight and age is a possible explanation for this finding. Large and dense tissues are hard to be positioned between the blades of the device and connective and fatty tissues necessitate multi-activation of the device. In addition, adherence of related tissue to the hot surface of the instrument, which is known as tissue sticking, intervenes with energy delivery that results in less effective and time-consuming sealing (6). In accordance with the results of the current study, significant effects of body weight and age of the animal on surgical time have been reported when bipolar electrosurgical forceps were used in canine orchiectomy (37).

The results have shown decreasing pain scores in both groups within 24 hours of surgery. In addition, the use of BVS device resulted in lower postoperative pain at 15 minutes and 1 hours of surgery. In dogs, the highest levels of postoperative pain are usually observed within the first 24 hours, and this time frame is evaluated in most clinical studies. It is known that the pain after surgical castration is high in the first hours and decreases afterward (21). It is suggested that shorter surgery time and decreased tissue trauma and handling with the BVS technique are responsible for the lower postoperative pain measured within 1 h of surgery.

Our results showing similar pain scores in study groups at 2 and 24 hours suggest that both ligation and BVS techniques caused comparable discomfort at these time points. Rescue analgesia was not required for any dogs in the current study. Reportedly, male dogs subjected to orchiectomy require less postoperative analgesia intervention than female dogs submitted to ovariohysterectomy (31). In agreement with our findings, no pain in 72.3% of dogs, mild discomfort in 25.0%, and mild to moderate pain in 2.7% of dogs were reported at 24 h after castration of 1066 dogs and rescue analgesia was not required (2). Similarly, rescue analgesia was not required for any of 34 dogs subjected to open castration as determined by the use of the Glasgow Composite Measure Pain Scale short form (13).

Post-surgical pain control in dogs is usually achieved by using opioids, non-steroidal anti-inflammatory drugs, local anaesthetics or their combinations. Non-steroidal anti-inflammatory drugs are effective for 12-24 hours and are commonly used in the clinical management of post-surgical pain and inflammation in dogs (20, 25). Meloxicam has been reported to provide adequate analgesia in dogs up to 72 hours after castration (23). In a study using 12 male dogs, pre-emptive meloxicam analgesia was found 100 % successful in terms of Modified Glasgow Pain Scale rescue analgesia requirement within 24 hours of surgery (31). Our findings provide further evidence that pre-emptive analgesia with meloxicam is an effective method of controlling postoperative pain for 24 hours in dogs undergoing open castration.

One of the limitations of the present study is that the pain score evaluation form used relies on subjective assessments. Using a better objectivity-validated scale could contribute to improving the reliability of the results. Ease of application and less disturbance to dogs were the main reasons for the selection of pain score evaluation form used. In addition, the use of the Elizabethan collar posed the risk to intervention with expressions related to attention to the wound and response to touch.

Increased incidence of surgical site complications was previously associated with increased surgery time for canine orchiectomy (17). However, the current study showed no evidence of a relationship between the duration of surgery and surgical site bruising and swelling scores indicating that the reduction in the duration of surgery was not the reason for lower surgical site complications in the BVS group. Lower surgical site swelling and bruising scores in the BVS group were possibly due to better haemostasis and less tissue handling and damage. Haemorrhage following orchiectomy is usually related to bleeding from the tunic causing self-limiting incisional haemorrhage, subcutaneous bruising, and scrotal hematoma (1). In addition, poor pain management contributes to increased surgical site complications or result in self-inflicted trauma (2). By simultaneous application of sealer designed to grasp and cut the formed seal with a blade incorporated into the jaws of the instrument, it was possible to perform a less invasive procedure with no risk of ligature slippage and any foreign material left.

Safety against the lateral spread of thermal effects associated with the use of an electrothermal BVS devices has been investigated extensively. In general, the use of an electrothermal BVS device results in a minimal lateral spread of thermal effects. The energy delivered varies based on tissue density within the device forceps and precise amount of energy is delivered to the tissue, limiting collateral thermal damage to <2.5 mm (12, 14) Limited thermal spread and collateral tissue injury have been reported for the system used in this study. Person et al. (29) reported that the thermal spread of the LigaSure™ system is limited to an area less than 1.5 mm beyond the tissue bundle or vessel.

When using electrothermal BVS devices, maintaining a safe distance from important anatomic structures, avoiding continuous use of the device and cooling after prolonged application are suggested (9). These considerations did not cause any major problems in this study due to the relative simplicity of the procedure and ease in accessibility of anatomical structures. Furthermore, only a few instrument activations were needed in each case.

Another limitation of the present study is the short follow-up time. The discontinuation beyond 24 h was because of routine practices for privately-owned dogs. Although the owners were advised to examine their dogs and surgical wound and no complications were reported in any dog, a longer follow-up period would have been valuable. Besides, the use of prophylactic antibiotics and antimicrobial spraying of the surgical site may have affected the representation of surgical site complications. The use of antibiotics is a controversial area of elective castration in dogs. It is important to emphasize that no protocol used in this study should be evaluated as best practice. Elective orchiectomy is considered as a clean surgical procedure and antimicrobial use is not usually advised unless the surgery is prolonged or there is an obvious break in asepsis causing contamination of the wound (5).

In conclusion, the use of a vessel sealing device was associated with significantly shorter surgery times and lower postoperative pain and surgical site complications compared with the use of conventional ligation technique in canine open orchiectomy, possibly because of better haemostasis and less tissue handling and damage.

## Acknowledgements

This work was orally presented at the 23rd European Veterinary Society for Small Animal Reproduction (EVSSAR) Congress, Virtual Congress 1-2 October 2021. This study was prepared from PhD thesis of the first author.

## Financial Support

This research received no grant from any funding agency/sector.

## Conflict of Interest

The authors declared that there is no conflict of interest.

## Author Contributions

CY and HK contributed to the design and implementation of the research and to the analysis of the results. HK wrote the manuscript in consultation with CY.

## Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

## Ethical Statement

The study protocol was reviewed and approved (Approval no: 2017-4-30) by the Local Ethics Committee on Animal Experiments, Ankara University, Türkiye.

## Animal Welfare

The authors confirm that they have adhered to ARRIVE Guidelines to protect animals used for scientific purposes.

## References


1. **Adin CA** (2011): *Complications of ovariohysterectomy and orchiectomy in companion animals*. Vet Clin North Am Small Anim, **41**, 1023-1039.
2. **Airikkala-Otter I, Gamble L, Mazeri S, et al** (2018): *Investigation of short-term surgical complications in a low-resource, high-volume dog sterilisation clinic in India.* BMC Vet Res, **14**, 56.
3. **Belanger JM, Bellumori TP, Bannasch DL, et al** (2017): *Correlation of neuter status and expression of heritable disorders*. Canine Genet Epidemiol, **26**, 4-6.
4. **Boothe HW** (2003): Testes and Epididymides. 1521-1530. In: D Slatter (Ed), Textbook of Small Animal Surgery. WB Saunders, Philadelphia.
5. **BSAVA** (2016): BSAVA Guide to the Use of Veterinary Medicines. British Small Animal Veterinary Association, Gloucester.
6. **Chekan E, Davison M, Singleton D, et al** (2015): *Consistency and sealing of advanced bipolar tissue sealers*. Med Devices (Auckl), **8**, 193-199.
7. **De la Puerta B, Baines S** (2012): *Surgical diseases of the genital tract in male dogs 1. Scrotum, testes and epididymides*. In Pract, **34**, 58-65.
8. **Devriendt N, Van Goethem B, Van Brantegem L, et al** (2017): *Comparison of a 5-mm and 10 mm vessel sealing device in an open ovariectomy model in dogs*. Vet Rec, **180**, 425.
9. **Eberli D, Helermehl LJ, Müller A, et al** (2011): *Thermal spread of vessel-sealing devices evaluated in a clinically relevant in vitro model*. Urol Int, **86**, 476-482.
10. **Freeman LJ, Ferguson N, Fellenstein C, et al** (2017): *Evaluation of learning curves for ovariohysterectomy of dogs and cats and castration of dogs*. J Am Vet Med, **251**, 322-332.
11. **Gardeweg S, Bockstahler B, Dupre G** (2019): *Effect of multiple use and sterilization on sealing performance of bipolar vessel sealing devices.* Plos One, **14**, e0221488.
12. **Goldstein SL, Harold KL, Lentzner A** (2002): *Comparison of thermal spread after ureteral ligation with the ultrasonic shears and LigaSure system*. J Laparoendosc Adv Surg Tech, **12**, 61-63.
13. **Hamilton KH, Henderson ER, Toscano M, et al** (2014): *Comparison of post-operative complications in healthy dogs undergoing open and closed orchidectomy*. J Small Anim Pract, **55**, 521-526.
14. **Harold KL, Pollinger H, Matthews BD, et al** (2003): *Comparison of ultrasonic energy, bipolar thermal energy, and vascular clips for the hemostasis of small-, medium-, and large-sized arteries*. Surg Endosc, **17**, 1228-1230.
15. **Hedlund C** (2007): Surgery of the Male Reproductive Tract. 714-715. In: TW Fossum (Ed), Small Animal Surgery. Mosby, St. Louis.
16. **Heniford BT, Matthews BD, Sing RF, et al** (2001): *Initial results with an electrothermal bipolar vessel sealer.* Surg Endosc, **15**, 799-801.
17. **Howe LM** (1997): *Short-term results and complications of prepubertal gonadectomy in cats and dogs.* J Am Vet Med, **211**, 57-62.
18. **Howe LM** (2006): *Surgical methods of contraception and sterilization*. Theriogenology, **66**, 500-509.
19. **Kennedy JS, Stranahan PL, Taylor KD, et al** (1998): *High-burst strength, feedback-controlled bipolar vessel sealing*. Surg Endosc, **12**, 876-878.
20. **Kum C, Voyvoda H, Sekkin S, et al** (2013): *Effects of carprofen and meloxicam on C-reactive protein, ceruloplasmin, and fibrinogen concentrations in dogs undergoing ovariohysterectomy*. Am J Vet Res, **74**, 1267-1273.
21. **Kushnir Y, Toledano N, Cohen L, et al** (2017): *Intratesticular and incisional line infiltration with ropivacaine for castration in medetomidine-butorphanol-midazolam sedatand dogs*. Vet Anaesth Analg, **44**, 346-355.
22. **Kustritz MV** (2007): *Determining the optimal age for gonadectomy of dogs and cats.* J Am Vet Med, **231**, 1665-1675.
23. **Leece EA, Brearley JC, Harding EF** (2005): *Comparison of carprofen and meloxicam for 72 hours following ovariohysterectomy in dogs*. Vet Anaesth Analg, **32**, 184-192.
24. **Lorange M, De Arburn Parent R, Huneault L, et al** (2019): *Use of a vessel-sealing device versus conventional hemostatic techniques in dogs undergoing thyroidectomy because of suspected thyroid carcinoma*. J Am Vet Med, **254**, 1186-1191.
25. **Mathews KA** (2002): *Non-steroidal anti-inflammatory analgesics: A review of current practice*. J Vet Emerg Crit Care, **12**, 89-97.
26. **Neilson JC, Eckstein RA, Hart BL, et al** (1997): *Effects of castration on problem behaviors in male dogs with reference to age and duration of behavior*. J Am Vet Med, **211**, 180-182.
27. **Ohlund M, Höglund O, Olsson U, et al** (2011): *Laparoscopic ovariectomy in dogs: a comparison of the LigaSureTM and the SonoSurg TM systems*. J Small Anim Pract, **52**, 290-294.
28. **Parkinson TJ** (2012): *Progress towards less invasive veterinary surgery.* Vet Rec, **171**, 67-68.
29. **Person B, Vivas DA, Ruiz D, et al** (2008): *Comparison of four energy-based vascular sealing and cutting instruments: A porcine model*. Surg Endosc, **22**, 534-538.
30. **Pollari FL, Bonnett BN** (1996): *Evaluation of postoperative complications following elective surgeries of dogs and cats at private practices using computer records.* Can Vet J, **37**, 672-678.
31. **Quarterone C, Luna SPL, Crosignani N, et al** (2017): *Ovariohysterectomy requires more post-operative analgesia than orchiectomy in dogs and cats*. Can Vet J, **58**, 1191-1194.
32. **Schwarzkopf I, Van Goethem B, Vandekerckhove PM, et al** (2015): *Vessel sealing versus suture ligation for canine ovarian pedicle haemostasis: a randomised clinical trial.* Vet Rec, **176**, 125.
33. **Shaver SL, Larrosa M, Hofmeister EH** (2019): *Factors affecting the duration of anesthesia and surgery of canine and feline gonadectomies performed by veterinary students*

*in a year-long predinical surgery laboratory*. Vet Surg, **48**, 352-359.

34. **Sindram D, Martin K, Medows JP, et al** (2011): *Collagen-elastin ratio predicts burst pressure of arterial seals created using a bipolar vessel sealing device in a porcine model.* Surg Endosc, **25**, 2604-2612.
35. **Stevens BJ, Posner LP, Jones CA, et al** (2013): *Comparison of the effect of intratesticular lidocaine/bupivacaine vs. saline placebo on pain scores and incision site reactions in dogs undergoing routine castration*. Vet J, **196**, 499-503.
36. **Wagner AE, Worland GA, Glawe JC, et al** (2008): *Multicenter, randomized controlled trial of pain-related behaviors following routine neutering in dogs*. J Am Vet Med, **233**, 109-115.
37. **Watts J** (2018): *The use of bipolar electrosurgical forceps for haemostasis in open surgical ovariectomy of bitches and queens and castration of dogs*. J Small Anim Pract, **59**, 465-473.
38. **White RN** (1998): Surgery of the Genital Tract. 171-196. In: GM Simpson, GCW England, M Havery (Eds), BSAVA Manual of Small Animal Reproduction and Neonatology. British Small Animal Veterinary Association, Cheltenham.
39. **Wouters EG, Buishand FO, Kirpensteijn J** (2011): *Use of a bipolar vessel-sealing device in resection of canine insulinoma*. J Small Anim Pract, **52**, 139-145.
40. **Wright T, Singh A, Mayhew PD, et al** (2016): *Laparoscopic-assisted splenectomy in dogs: 18 cases (2012-2014)*. J Am Vet Med, **248**, 916-922.

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DOI: 10.33988/auvfd.1092062