Use of a vessel-sealing device versus conventional hemostatic techniques in dogs undergoing thyroidectomy because of suspected thyroid carcinoma

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OBJECTIVE
To compare use of a vessel-sealing device (VSD) versus conventional hemostatic techniques in dogs undergoing thyroidectomy because of suspected thyroid carcinoma.

DESIGN
Retrospective cohort study.

ANIMALS
42 client-owned dogs undergoing thyroidectomy because of suspected thyroid carcinoma.

PROCEDURES
Medical records of dogs treated at 4 referral centers from 2010 through 2016 were reviewed, and information was obtained on patient signalment, surgical technique, tumor-specific factors, and operative duration. Postoperative hospitalization time and complications were compared between dogs grouped on the basis of hemostatic technique.

RESULTS
Thyroidectomy was performed with a VSD in 23 dogs and with conventional hemostatic techniques (ie, ligatures, hemoclips, or electrocautery) in 19 dogs. Hemostatic technique (ie, use of a VSD vs conventional hemostatic techniques) was the only factor significantly associated with operative duration (median time, 28 vs 41 minutes). Postoperative hospitalization times and complication rates did not differ between groups.

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested that use of a VSD, rather than conventional hemostatic techniques, in dogs undergoing thyroidectomy because of suspected thyroid carcinoma resulted in shorter operative times without significantly affecting complication rates or postoperative hospitalization times. (J Am Vet Med Assoc 2019;254:1186–1191)

Thyroidectomy is the recommended treatment for dogs with nonmetastatic thyroid carcinoma in which the thyroid mass is mobile.1–5 However, thyroidectomy can be a challenging surgical procedure because of the vascularity of thyroid carcinomas and the potential for intraoperative bleeding resulting in hypotension and difficulties visualizing the operative field. Additional challenges of the procedure include identification and preservation of important regional anatomic structures (eg, vagal and recurrent laryngeal nerves and esophagus) as well as identification and appropriate management of macroscopic tumor thrombi and bilateral thyroid carcinomas.1,4–7,a

Several previous studies8–15 have evaluated the efficacy and safety of VSDs in dogs, and these devices are now widely used in many surgical procedures. Vessel-sealing devices reportedly require a shorter time than mechanical ligation techniques to provide hemostasis, do not leave any foreign material in the surgical wound, remove the risk of ligature slippage, require no or only minimal surgical dissection before application, and create seals comparable in strength to mechanical ligation techniques.16 Their unique mechanism of action allows for rapid and reliable hemostasis of vessels up to 7 mm in diameter.15 The heat generated by the high current and low voltage of VSDs results in denaturation of collagen and elastin fibers within the tissue bundle and blood vessels.17 The simultaneous application of pressure with the device forceps causes vessel wall apposition and rearrangement of the proteins into a hemostatic seal.15,17,18 When a VSD is used, the energy delivered varies on the basis of tissue density within the device forceps, limiting collateral thermal damage to < 2.5 mm.16,19–21

In people undergoing thyroidectomy, VSDs result in improved accuracy of hemostasis and shorter surgical times, and VSDs are now considered the gold standard for performing thyroidectomies in people.22,23 To the best of our knowledge, however, use of a VSD for thyroidectomy in dogs has not been reported. Instead, conventional techniques such as ligatures, hemoclips, and monopolar electrocautery are typically used to accomplish hemostasis during thyroidecto-
The purpose of the study reported here was to compare use of a VSD with use of these conventional hemostatic techniques in dogs undergoing thyroidectomy because of suspected thyroid carcinoma. We hypothesized that operative times would be shorter when a VSD was used than when conventional hemostatic techniques were used, but that postoperative hospitalization times and complications rates would not differ between groups.

**Materials and Methods**

**Case selection**

The medical records databases of 4 referral centers in Canada (Centre Vétérinaire Rive-Sud, Centre Vétérinaire DMV, VCA Canada–Alta Vista Animal Hospital, and Centre Vétérinaire Laval) were searched to identify dogs that underwent thyroidectomy between January 2010 and September 2016 because of suspected thyroid carcinoma. Dogs were excluded from the study if the medical record was incomplete or if any other surgical procedure was performed concurrently with thyroidectomy.

**Medical records review**

Medical records of dogs included in the study were reviewed. Patient-specific characteristics that were recorded consisted of age, sex, and body weight at the time of surgery. Tumor-specific characteristics that were recorded consisted of tumor mobility (determined subjectively as mobile or fixed on the basis of results of palpation), tumor measurements (determined with a sliding caliper or on ultrasonographic images), affected side, serum thyroxine and thyroid-stimulating hormone concentrations, whether there was macroscopic evidence of vascular or local invasion at the time of surgery, tumor type, and clinical stage. Technique-specific characteristics that were recorded consisted of hemostatic technique and operative time. Other pertinent information retrieved from the medical records included postoperative hospitalization time and whether any intra- or postoperative complications developed.

For purposes of statistical analyses, dogs were allocated to 2 groups on the basis of hemostatic technique: VSD or conventional hemostatic techniques (ie, ligatures, hemoclips, or electrocautery). The decision to use a particular hemostatic technique depended on availability of a VSD in each center and surgeon preference.

Complications were classified as intraoperative (occurring from the time of the initial skin incision to the time of final surgical closure) or postoperative (occurring any time after surgical closure), with postoperative complications further divided into immediate (occurring within the first 24 hours after surgical closure) or intermediate (occurring between 24 hours and 14 days after surgery). Complications requiring further veterinary intervention or that led to death or euthanasia were classified as major complications, and complications that were self-limiting were classified as minor complications. Postoperative hypocalcemia and hypothyroidism following bilateral thyroidectomy were not considered complications because these were expected results of the procedure.

**Surgical technique**

Anesthetic protocol varied according to surgeon preference. Dogs were positioned in dorsal recumbency, and a standard ventral midline approach to the thyroid glands was performed. The paratracheal fascia was incised, taking care to not penetrate the tumor capsule, and surrounding tissues were retracted with Gelpi or Balfour retractors. Sharp (VSD or scissors) or blunt (finger, scissors, or sterile swab) dissection was then used to free the affected thyroid lobe from the surrounding tissues. Hemostasis of the cranial and caudal thyroid arteries and veins and any other vessels associated with the tumor was achieved with a VSD or by means of conventional hemostatic techniques (ie, ligatures, hemoclips, or monopolar or bipolar electrocautery). The same device was used for all patients in the VSD group. Every effort was made to identify and protect important regional structures such as the recurrent laryngeal nerve, jugular vein, carotid artery, vagosympathetic trunk, esophagus, and trachea. Following tumor removal, the surgical site was lavaged with sterile saline (0.9% NaCl) solution, and the incision was closed routinely. Regional lymph nodes (mandibular and medial retropharyngeal lymph nodes) were not routinely biopsied, and the decision to do so varied according to primary clinician. The choice of postoperative antimicrobial and analgesic treatment varied according to surgeon preference. Wide resection was not undertaken in any of these procedures, no neurovascular structures were ligated, no drains were placed, and preservation of the ipsilateral parathyroid glands was not attempted.

**Statistical analysis**

The Shapiro-Wilk test was used to determine whether continuous data were normally distributed, and patient-specific and tumor-specific characteristics were then compared between hemostatic technique groups. Student t tests were used to compare normally distributed variables (ie, age, body weight, and tumor measurements) between groups, and Wilcoxon rank sum tests were used to compare nonnormally distributed variables (ie, operative time and years since the surgeon became board certified) between groups. For categorical variables, Fisher exact tests were used to test whether values differed between hemostatic technique groups.

Multivariate regression was used to identify variables that were significantly associated with operative time. The dependent variable was log-transformed operative time in minutes. Independent variables that were evaluated consisted of age, body weight, sex (sexually intact male, neutered male, sexually intact female, or neutered female), tumor type (adenoma or carcinoma), tumor measurement, affected side (bilateral or unilateral), serum thyroxine and thyroid-stimulating hormone concentrations (hypothyroid, normal, or hyperthyroid),
macroscopic vascular invasion (yes or no), macroscopic tissue invasion (yes or no), World Health Organization stage, years since the surgeon became board certified, and hemostatic technique (VSD or conventional techniques). Each independent variable was first evaluated by means of univariate regression analysis. Then, multivariate regression analysis incorporating a stepwise method was performed. The coefficient of determination (\(R^2\)) was used as a measure of the amount of variance in operative time that was explained by the independent variables retained in the final regression model.

Missing values were handled by means of the listwise case exclusion method. All statistical analyses were performed with standard statistical software, with values of \(P < 0.05\) considered significant. Normally distributed data were summarized as mean and SD; nonnormally distributed data were summarized as median and interquartile (25th to 75th percentile) range.

Results

Forty-six dogs underwent thyroidectomy at the 4 participating hospitals during the study period; however, 4 dogs were excluded because they underwent additional surgical procedures at the same time as thyroidectomy (excisional biopsy of the retropharyngeal and mandibular lymph nodes, \(n = 3\); cutaneous mass excision, 1). The remaining 42 dogs were included in the study.

Of these 42 dogs, 23 underwent thyroidectomy with a VSD, and 19 underwent thyroidectomy with the use of conventional hemostatic techniques. During preoperative palpation, thyroid masses were considered to be mobile in 39 dogs; masses could not be palpated in the remaining 3 dogs (2 in the conventional hemostatic technique group and 1 in the VSD group). The association between tumor mobility and operative time could not be evaluated because none of the dogs had fixed tumors. Forty dogs underwent preoperative 3-view thoracic radiography and 1 underwent preoperative thoracic CT; none of these dogs had any evidence of pulmonary metastases. Two dogs (1 in each group) underwent fine-needle aspiration of mandibular lymph nodes prior to surgery; for both dogs, results of cytologic evaluation of the aspirates were consistent with lymphoid hyperplasia. Patient- and tumor-specific characteristics for each group were summarized (Table 1). None of these characteristics were significantly different between

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>VSD</th>
<th>Conventional</th>
<th>(P) value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>9.1 (1.9)</td>
<td>10.4 (3.0)</td>
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<tr>
<td>Body weight (kg)</td>
<td>19.5 (10.4)</td>
<td>23.0 (12.3)</td>
<td>0.328</td>
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<td>Sex</td>
<td></td>
<td></td>
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<tr>
<td>Neutered male</td>
<td>13</td>
<td>9</td>
<td>0.757</td>
</tr>
<tr>
<td>Neutered female</td>
<td>9</td>
<td>9</td>
<td>0.755</td>
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<tr>
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<td>1</td>
<td>0.452</td>
</tr>
<tr>
<td>Sexually intact female</td>
<td>1</td>
<td>0</td>
<td>0.999</td>
</tr>
<tr>
<td>Maximum tumor diameter (cm)</td>
<td>3.8 (1.8)</td>
<td>4.0 (1.6)</td>
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<tr>
<td>Affected lobe</td>
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<td></td>
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</tr>
<tr>
<td>Unilateral</td>
<td>21</td>
<td>18</td>
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</tr>
<tr>
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<tr>
<td>WHO stage†</td>
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</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>0.450</td>
</tr>
<tr>
<td>II</td>
<td>18</td>
<td>14</td>
<td>0.999</td>
</tr>
<tr>
<td>III</td>
<td>4</td>
<td>3</td>
<td>0.999</td>
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<tr>
<td>Thyroid hormone concentrations†</td>
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</tr>
<tr>
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<tr>
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<tr>
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<td>16</td>
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<tr>
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<td>6</td>
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</tr>
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<td>17</td>
<td>18</td>
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</tr>
<tr>
<td>Time since board certification (y)</td>
<td>5 (5–12)</td>
<td>12 (7–12)</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Data are reported as mean (SD), median (interquartile [25th to 75th percentile] range), or number of dogs. *\(P\) values were obtained with Student \(t\), Wilcoxon rank sum, or Fisher exact tests. †Information was not available for all dogs.

NA = Not applicable. WHO = World Health Organization.
groups except for time since the surgeon had become board certified.

**Operative time**

Operative time was significantly ($P = 0.019$) shorter in dogs that underwent thyroidectomy with a VSD (median, 28 minutes; interquartile range, 23 to 37 minutes) than in dogs in which conventional hemostatic technique were used (median, 41 minutes; interquartile range, 28 to 65 minutes). On univariate regression, the only variable significantly associated with operative time was hemostatic technique. Similarly, on multivariate regression, hemostatic technique was the only variable significantly ($P = 0.008; R^2 = 0.17$) associated with operative time.

**Complications**

Major complications were reported in 3 dogs in which conventional hemostatic techniques were used. One dog developed acute bleeding from the surgical incision 3 hours after the procedure, and additional surgery was required to identify and ligate the bleeding vessel. A second dog developed a large hematoma (10 to 12 cm in diameter) at the surgery site overnight, and this dog died while under sedation to manage the hematoma (CPR was unsuccessful). The third dog developed hypothyroidism for which transient supplementation was needed. None of the dogs in the conventional hemostatic techniques group developed minor complications.

Four dogs in which a VSD was used had major complications. One dog had iatrogenic esophageal perforation when the esophagus was inadvertently included in the jaws of the VSD. This was a 12-kg (26-lb) 11-year-old Dachshund that was not known to have any other concurrent medical conditions. The esophageal perforation was small and was debrided and sutured with a 2-layer simple continuous suture technique. However, the wound dehisced and did not respond to 2 additional attempts at closure, and the dog was euthanized 8 days after the initial surgery. Two dogs developed aspiration pneumonia and were treated with antimicrobials and oxygen therapy. The remaining dog developed hypocalcemia in the immediate postoperative period and required transient calcium supplementation. All 3 dogs were successfully discharged from the hospital. None of the dogs in the VSD group developed minor complications.

Other than the esophageal perforation, all complications developed in the immediate postoperative period. The proportion of dogs that developed complications did not differ between the conventional hemostatic techniques group (3/19 [16%]; 95% confidence interval, 10.7% to 20.2%) and the VSD group (4/23 [17%]; 95% confidence interval, 7.1% to 42.1%).

**Postoperative hospitalization time**

Of the 19 dogs in the conventional hemostatic techniques group, 16 (84%) were discharged the day after surgery, 1 (5%) was discharged 2 days after surgery, and 1 (5%) was discharged 5 days after surgery (the remaining dog died). Of the 23 dogs in the VSD group, 17 (74%) were discharged the day after surgery, 4 (17%) were discharged 2 days after surgery, and 1 (4%) was discharged 3 days after surgery (the remaining dog died). The proportion of dogs discharged the day after surgery did not differ between the conventional hemostatic techniques group (16/19 [84%]; 95% confidence interval, 59.7% to 94.8%) and the VSD group (17/23 [74%]; 95% confidence interval, 53.2% to 90.2%).

**Discussion**

Results of the present study suggested that use of a VSD, rather than conventional hemostatic techniques, in dogs undergoing thyroidectomy because of suspected thyroid carcinoma resulted in shorter operative times without significantly affecting complication rates or postoperative hospitalization times. Of the variables evaluated, only hemostatic technique was identified as a significant predictor of operative time. Although surgeon experience (ie, years since board certification) was significantly different between groups, this variable was not found to be significant in multivariate regression modeling. Furthermore, the difference in surgeon experience should have favored the conventional hemostatic techniques group.

No intraoperative or immediate postoperative bleeding was reported for dogs in the VSD group in the present study, whereas 2 dogs in the conventional hemostatic techniques group had bleeding-related complications in the immediate postoperative period. The cause of bleeding was not specified in the medical records of these dogs, but ligature slippage or unidentified bleeding vessels could have played a role in both dogs. The thyroid gland is highly vascularized, and thyroidectomy has previously been associated with a high risk for hemorrhage. For example, bleeding was the most common complication in a recent retrospective case series in which 5 of 88 (5.7%) dogs undergoing thyroidectomy required a blood product transfusion. In another retrospective case series, 4 of 15 dogs that underwent bilateral thyroidectomies had clinically relevant intraoperative bleeding, with 2 of those dogs requiring blood transfusions. Although the effect of intraoperative bleeding on long-term outcome in dogs undergoing thyroidectomy has not been specifically evaluated, a previous study found that survival times were shorter in dogs that received perioperative RBC transfusions. For the present study, the number of dogs in the VSD group was small (n = 23). Nevertheless, none of these dogs had intraoperative or immediate postoperative bleeding. Thus, use of a VSD for thyroidectomy in dogs may be preferable to conventional hemostatic techniques, as is the case for people, because of shorter surgical times and a lower risk of intraoperative bleeding.

One dog in the present study developed a major complication directly related to use of the VSD. In
this dog, the VSD was used for both dissection and hemostasis. Unfortunately, poor appreciation of tissue within the jaws of the VSD resulted in trauma to both the esophagus and vagus nerve. As a result of this case, the authors now suggest use of blunt dissection to separate the thyroid mass from nerves, the esophagus, and the trachea, followed by use of the VSD to cauterize and resect residual fascia, vascular structures, and the cranial and caudal thyroid arteries. Primary blunt dissection and secondary cauterization of isolated vessels with the VSD was the preferred technique for most surgeons who operated on dogs in the present study. Preliminary identification and protection of structures in this region as well as adequate visualization of tissue within the jaws after applying heat or cutting would seem to be important for minimizing major iatrogenic complications. Some surgeons used orogastric tubes to better identify the esophagus during surgery.

Lateral spread of thermal effects can be a concern when using any electrosurgery unit, especially when working in proximity to delicate structures. In dogs undergoing thyroidectomy, iatrogenic damage to the recurrent laryngeal nerve and resultant unilateral laryngeal paralysis have been described as a complication.14,15 In human medicine, postoperative laryngeal nerve palsy is a major concern after thyroidectomy, and routine evaluation of laryngeal nerve function is the current standard of care.27 Laryngeal nerve damage was not suspected in any of the dogs in the present study; however, laryngeal function was not routinely evaluated.

Lateral spread of thermal effects associated with use of a VSD has been investigated in clinical studies involving people and in ex vivo studies;16,18,28–30 In general, use of a VSD resulted in minimal lateral spread of thermal effects, and the heat generated was mostly localized between the jaws of the forceps.16,18 In a prospective study30 of human patients undergoing thyroidectomy, a VSD had a safer heat dissipation margin, compared with other hemostatic devices. The authors of that study also concluded that device functioning time had an important influence on the thermal safety margin. As a result, the authors suggested not only that a safe distance from important anatomic structures should be maintained but also that the device should not be used continuously and that cooling should be considered after prolonged application.30

Limitations of the present study included the small sample size and retrospective design. The hemostatic technique used in each dog was based on clinician preference and availability of a VSD in each hospital. Follow-up information on outcome beyond the perioperative period was not included in the present study because determining long-term outcome was not a goal of the study. A selection bias toward small mobile masses may have been present in our study population because of previous recommendations to surgically treat these masses.

Regardless of the hemostatic technique used, thyroidectomy was associated with a low complication rate in the present study, and most complications that did occur could be managed medically. Use of a VSD was associated with significantly shorter operative times, compared with use of conventional hemostatic techniques, possibly because better hemostasis led to improved visualization. Despite their advantages, VSDs should be used with caution because of the potential for iatrogenic complications.

Acknowledgments
The authors declare that there were no conflicts of interest. The authors thank Drs. Romain Béraud, Jacques Dupuis, and Jérôme Benamou for providing case information and images and Dr. Maxim Moreau for performing the statistical analyses.

Footnotes

References
Effects of orally administered raltegravir in cats with experimentally induced ocular and respiratory feline herpesvirus-1 infection

Chloe B. Spertus et al

OBJECTIVE
To determine the effects of orally administered raltegravir in cats with experimentally induced ocular and respiratory feline herpesvirus-1 (FHV-1) infection.

ANIMALS
14 healthy 6-month-old unvaccinated specific pathogen–free cats.

PROCEDURES
On day 0, all cats were experimentally inoculated by topical application of 0.1 mL of a solution containing 10⁶ plaque-forming units of FHV-1 strain FH2CS to the inferior conjunctival fornix of each eye. Cats were randomly assigned to receive either raltegravir (80 mg; n = 7) or lactose (250 mg; vehicle; 7), PO, every 12 hours for 14 days beginning on day 1. Cats were assigned clinical ocular and respiratory disease scores every other day from days 0 to 30. Conjunctival swab specimens were collected for detection of FHV-1 by virus isolation and real-time PCR assay at 3-day intervals from days 0 to 30. Confocal microscopy was performed on days 0 and 10 to assess corneal epithelial leukocyte infiltration. The assessed variables and duration of FHV-1 shedding were compared between the 2 treatment groups.

RESULTS
Cats in both groups developed moderate to severe conjunctivitis and ulcerative keratitis characteristic of FHV-1 infection. Median duration of FHV-1 shedding was shorter and signs of ocular and respiratory disease were less severe for raltegravir-treated cats than for vehicle-treated cats. However, the mean conjunctival FHV-1 titer and corneal epithelial leukocyte count did not differ between the 2 groups.

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested orally administered raltegravir might be effective for alleviation of ocular and respiratory signs of FHV-1 infection in cats. (Am J Vet Res 2019;80:490–497)