Effects of a transdermal lidocaine patch on indicators of postoperative pain in dogs undergoing midline ovariohysterectomy

Danielle K. Merema BVMS
Emily K. Schoenrock DVM
Kevin Le Boedec DVM, MS
Maureen A. McMichael DVM

From the Departments of Veterinary Clinical Medicine (Merema, Schoenrock, McMichael) and Comparative Biosciences (Le Boedec), College of Veterinary Medicine, University of Illinois, Urbana, IL 61802. Dr. Schoenrock’s present address is Department of Veterinary Clinical Sciences, College of Veterinary Medicine, Iowa State University, Ames, IA 50014. Dr. Le Boedec’s present address is Internal Medicine Unit, CHV Fregis, 43 Ave Aristide Briand, 94110 Arcueil, France.

Address correspondence to Dr. McMichael (mmcm@illinois.edu).

OBJECTIVE
To determine the effects of a transdermal lidocaine patch (TLP) on indicators of postoperative pain in healthy dogs following ovariohysterectomy.

DESIGN
Randomized, blinded controlled trial.

ANIMALS
40 healthy shelter-owned female dogs admitted to a student surgery program for ovariohysterectomy.

PROCEDURES
Dogs were randomly assigned to receive after ovariohysterectomy a 5-cm-wide strip of TLP applied topically on both sides of the incision, for the full length of the incision and a wound dressing (n = 19) or a placebo patch (nonmedicated wound dressing; 21). All dogs underwent midline ovariohysterectomy. Immediately afterward, dogs received 2 IM morphine injections, carprofen (SC, q 12 h for 2 days), and the assigned patch (left in place for 18 hours). Postoperative comfort was evaluated by use of the short form of the Glasgow Composite Measures Pain Scale and serum cortisol concentrations measured prior to premedication and 1, 2, 4, 6, 8, 10, and 18 hours after surgery.

RESULTS
No significant difference in pain scores or serum cortisol concentrations was identified between dogs that received the TLP and dogs that received a placebo patch after ovariohysterectomy.

CONCLUSIONS AND CLINICAL RELEVANCE
The TLP provided no additional analgesic benefit to dogs treated concurrently with recommended doses of morphine and carprofen following ovariohysterectomy. Additional studies are needed to investigate whether similar results might be achieved in dogs treated concurrently with other analgesics. (J Am Vet Med Assoc 2017;250:1140–1147)

Unauthenticated | Downloaded 01/13/24 07:11 PM UTC
that TLP application results in minimal systemic absorption of lidocaine, thereby providing a low risk of adverse systemic effects and interdrug interactions. To the authors’ knowledge, no studies have been conducted to investigate the effects of TLP application on postoperative pain in veterinary patients.

The objective of the study reported here was to determine the effects of a TLP on postoperative pain in healthy dogs. We hypothesized that application of the TLP versus a placebo patch would result in fewer signs of postoperative pain during the 18-hour period following ovariohysterectomy, as indicated by lower CMPS-sf scores and lower serum cortisol concentrations.

**Materials and Methods**

**Animals**

Healthy, sexually intact female dogs of various ages and breeds admitted from local shelters to the University of Illinois Veterinary Teaching Hospital for ovariohysterectomy between September 2014 and March 2015 were included in the study. Dogs arrived at the hospital 1 to 5 days prior to the day of surgery and were housed individually within student surgery wards. Health status of all dogs was confirmed through a complete physical exam and clinicopathologic testing that included measurement of PCV, serum total protein concentration, and blood glucose and BUN concentrations and a heartworm antigen test. Exclusion criteria included body weight < 15 kg (33 lb), systemic disease, dermatologic disease, and temperament inconducive to handling. The study protocol was approved by the University of Illinois Institutional Animal Care and Use Committee.

**Sample size determination**

Before the study began, a sample size calculation was performed on the basis of data from a previously reported study with a similar design. In accordance with those data, a clinically relevant difference in pain between groups could be defined as a difference between groups of > 1 unit in CMPS-sf score and > 2.1 µg/dL (58 nmol/L) in serum cortisol concentration. Other parameters in the sample size calculation included an α value of 0.006 (to account for 8 repeated assessments), an SD of 0.6 for CMPS-sf scores and 1.2 µg/dL for serum cortisol concentration, and a β value of 0.20. The calculation revealed that 9 dogs would be needed for each study group to detect the stated clinically relevant differences if they truly existed. Forty-six dogs were initially enrolled.

**Experimental design**

This study was designed as a randomized, blinded controlled trial. The study subjects and the surgery (midline ovariohysterectomy) they were to undergo were believed to provide a suitable, clinically relevant scenario for assessment of the analgesic properties of the TLP. An online random number generator was used to assign dogs to 2 treatment groups (TLP or placebo patch after surgery).

**Anesthesia and ovariohysterectomy**

Third-year veterinary students in a student surgery program performed all ovariohysterectomies. Food was withheld from dogs for the 12-hour period before surgery and the 2- to 6-hour period after surgery. Prior to surgery, each dog received dexmedetomidine hydrochloride (0.004 mg/kg [0.002 mg/lb], IM), morphine (0.50 mg/kg [0.23 mg/lb], IM), and atropine (0.04 mg/kg [0.02 mg/lb], IM). Anesthesia was induced by IV injection of propofol (4.0 mg/kg [1.8 mg/lb], to effect) and maintained with isoflurane in oxygen. Depth of anesthesia was monitored and controlled by third-year veterinary students under the supervision of certified veterinary technicians and veterinarians. Midline ovariohysterectomy was performed. Lactated Ringer solution was administered IV throughout anesthesia at a rate of 10 mL/kg/h (4.5 mL/lb/h).

At anesthetic recovery, all dogs received morphine (0.25 mg/kg [0.11 mg/lb], IM; plus 0.25 mg/kg, IV) and carprofen (2.2 mg/kg [1.0 mg/lb], SC). Carprofen was again administered 12 hours after surgery (approx 2.2 mg/kg, PO q, 12 h for 2 days in total).

**Treatment**

Immediately following skin closure and after cleaning and drying by a trained certified veterinary technician, surgical wounds were treated with TLP or placebo patch as assigned. The generic form of TLP was used for dogs assigned to the TLP group. The dose of TLP was selected on the basis of the dose indicated in a previous report; a 5-cm-wide strip of TLP was applied to both sides of the surgical incision, for the full length of the incision. This dose of TLP was applied 1 cm from the wound edge because the product is not sterile, and absorption across broken skin had not been investigated at the time the study was conducted. The incision and TLP were then covered with a nonmedicated, nonadhesive sterile wound dressing. For dogs assigned to the placebo group, no TLP and only the nonmedicated, nonadhesive, sterile wound dressing was applied following surgery.

In both groups, the wound dressing was covered with an abdominal bandage to prevent TLP ingestion and to maintain blinding of individuals performing the CMPS-sf scoring. An Elizabethan collar was also applied to all dogs to prevent TLP ingestion, despite a report that no adverse effects were detected following TLP ingestion by 1 dog. No hot or cold wound compresses were applied. Wound dressings were left undisturbed until 18 hours after surgery, when dressings were removed from dogs in both groups. Although the manufacturer of the TLP recommends that the TLP be left on the skin for a maximum of 12 hours a day, application for 72 hours has been demonstrated to be safe in dogs. Dogs were monitored in the hospital for 48 hours following surgery.

**General assessments**

Body weight at hospital admission, breed, and incision length were recorded for each dog. Incisions...
were evaluated by 1 of 5 blinded observers (4 third-year veterinary students and 1 certified veterinary technician) at 18, 36, and 42 hours following surgery for signs of inflammation, including erythema, urticaria, edema, warmth, and swelling. Scores were assigned on the basis of clinical judgment of the observer for each of these 5 characteristics (0 = none, 1 = mild, 2 = moderate, and 3 = severe). Scores were then summed, for a maximum possible score of 15 at each assessment point. Incisions were also monitored for signs of infection, including opaque discharge, rectal temperature > 39.2°C (102.5°F), and incisional odor. Dogs were monitored for wound dehiscence, wound herniation, cardiac arrhythmias, and any other complications. Forty-eight hours after surgery, dogs were either adopted or returned to the shelter for adoption.

Pain assessment and rescue analgesia

The CMPS-sf scores and serum cortisol concentrations were used as indicators of pain. Postoperative pain assessments were performed by 1 of 4 trained veterinary students or 1 certified veterinary technician (the same individuals who scored degrees of surgical wound inflammation), each of whom was blinded to treatment group assignment. All 5 observers were trained in the blood sample collection and serum-harvesting technique and use of the CMPS-sf. Training included verification that the observers understood the intended meaning of various descriptors used in the CMPS-sf. For example, it was clarified that the term unsettled was intended to describe a dog that was neither calm nor tranquil and that the term restless was intended to describe a dog that appeared unhappy and was moving about the cage.

At each assessment point, 1 of the 5 trained observers was randomly assigned to assess all dogs. The CMPS-sf consisted of 6 observational categories. The first 2 categories of scores were assigned by observation of the dog’s behavior while in its kennel (0 = quiet, 1 = crying or whimpering, 2 = groaning, and 3 = screaming) and its attention to any wound or painful anatomic region (0 = ignoring the region, 1 = looking at the region, 2 = licking the region, 3 = rubbing the region, and 4 = chewing the region). In the second portion, scores were assigned for the dog’s condition after it was allowed to walk in a leash and led out of the kennel (0 = normal, 1 = lame, 2 = slow or reluctant, 3 = stiff, and 4 = refuses to move). In the third portion, scores were assigned for behavior when gentle pressure was applied to the area 2 inches distal to the ovariohysterectomy site (0 = does nothing, 1 = looks around, 2 = flinches, 3 = growls or guards the area, 4 = snaps, and 5 = cries). In the final portion, scores were assigned for dog attitude (0 = happy and content or happy and bouncy, 1 = quiet, 2 = indifferent or nonresponsive to surroundings, 3 = nervous or anxious or fearful, and 4 = depressed or nonresponsive to stimulation) and appearance (0 = comfortable, 1 = unsettled, 2 = restless, 3 = hunched or tense, and 4 = rigid). Scores for all 4 portions were summed to achieve a total score with a maximum value of 24 (or 20 if mobility could not be assessed). A score of 5/20 or 6/24 is generally considered the point at which analgesic intervention is required.

Scoring on the CMPS-sf was performed prior to premedication for ovariohysterectomy (0 hours) and at 1, 2, 4, 6, 8, 10, and 18 hours following surgery. Surgery was considered to be finished once the incision had been closed. A protocol for rescue analgesia was in place such that any dog with a CMPS-sf score equal or greater than 6/24 or 5/20 would receive morphine (0.50 mg/kg, IM) and tramadol (4.0 to 5.0 mg/kg [1.8 to 2.3 mg/lb], PO) and be withdrawn from the study.

Serum cortisol assessment

Blood samples were collected via an indwelling 20-gauge, 5.1-cm cephalic catheter with a heparin lock system immediately after anesthetic induction and at 1, 2, 4, 6, 8, 10, and 18 hours following surgery. This method was chosen for serial sample collection because of its effectiveness and minimally invasive nature. Before the first sample was collected from each dog, the catheter was flushed with 5.0 mL of saline (0.9% NaCl) solution to ensure patency. To ensure the sample reflected circulating blood, 2.5 mL of blood was first drawn and discarded. Another 2.5 mL of blood was then drawn via a 22-gauge needle and transferred to a 2.5-mL serum separator tube. To maintain catheter patency, the catheter was then flushed with 5.0 mL of saline solution and 0.5 mL of heparinized saline solution (2 U of heparin/mL).

Collected blood samples were allowed to clot for 30 minutes before centrifugation at 3,500 × g for 10 minutes. The separated serum was then temporarily stored within the serum separator tubes at 4°C. Serum cortisol assessment was performed by 1 of 5 blinded observers (4 third-year veterinary students and 1 certified veterinary technician) at 18, 36, and 42 hours following surgery. This method was chosen for serial sample collection because of its effectiveness and minimal invasive nature. Before the first sample was collected from each dog, the catheter was flushed with 5.0 mL of saline (0.9% NaCl) solution to ensure patency. To ensure the sample reflected circulating blood, 2.5 mL of blood was first drawn and discarded. Another 2.5 mL of blood was then drawn via a 22-gauge needle and transferred to a 2.5-mL serum separator tube. To maintain catheter patency, the catheter was then flushed with 5.0 mL of saline solution and 0.5 mL of heparinized saline solution (2 U of heparin/mL).

Collected blood samples were allowed to clot for 30 minutes before centrifugation at 3,500 × g for 10 minutes. The separated serum was then temporarily stored within the serum separator tubes at 4°C. Within 12 hours after collection, serum was divided into 20-µL aliquots in plastic Eppendorf tubes. Serum samples were then stored at −62°C, which, although unconfirmed for measurement of cortisol concentration, is a widely accepted temperature for long-term serum storage and has been used in similar studies.

Serum cortisol assessment

Blood samples were collected via an indwelling 20-gauge, 5.1-cm cephalic catheter with a heparin lock system immediately after anesthetic induction and at 1, 2, 4, 6, 8, 10, and 18 hours following surgery. This method was chosen for serial sample collection because of its effectiveness and minimally invasive nature. Before the first sample was collected from each dog, the catheter was flushed with 5.0 mL of saline (0.9% NaCl) solution to ensure patency. To ensure the sample reflected circulating blood, 2.5 mL of blood was first drawn and discarded. Another 2.5 mL of blood was then drawn via a 22-gauge needle and transferred to a 2.5-mL serum separator tube. To maintain catheter patency, the catheter was then flushed with 5.0 mL of saline solution and 0.5 mL of heparinized saline solution (2 U of heparin/mL).

Collected blood samples were allowed to clot for 30 minutes before centrifugation at 3,500 × g for 10 minutes. The separated serum was then temporarily stored within the serum separator tubes at 4°C. Within 12 hours after collection, serum was divided into 20-µL aliquots in plastic Eppendorf tubes. Serum samples were then stored at −62°C, which, although unconfirmed for measurement of cortisol concentration, is a widely accepted temperature for long-term serum storage and has been used in similar studies.

One month following collection of the final blood samples, all serum samples were thawed over ice and cortisol concentration was measured at the University of Illinois Veterinary Diagnostic Laboratory by chemiluminescence assay. Reference limits for serum cortisol concentration established for dogs at that laboratory are 58 to 144 nmol/L.

Statistical analysis

Statistical analyses were performed by use of statistical software. Data distributions were evaluated for normality by means of histograms and the Shapiro-Wilk test. When the data distribution appeared Gaussian, the F test was performed to assess the variance of the data within each treatment group. Comparisons between TLP and placebo groups for variables measured once were performed by use of
the Student $t$ test (surgical incision length), Mann-Whitney test (body weight), and ordinal logistic regression (inflammation score).

The GCMP-sf scores and serum cortisol concentrations assessed over time were compared between treatment groups by means of repeated-measures ANOVA. Post hoc analyses were performed via pairwise comparisons of predictive margins with Bonferroni correction. Transformations (square root of CMPS-sf scores and square of the logarithm of the serum cortisol concentrations) were necessary to provide normality and homogeneity of variance (homoscedasticity) of residuals, and both characteristics were assessed graphically and by use of the Shapiro-Wilk and the Breusch-Pagan and Cook-Weisberg tests, respectively. Distribution of the residuals was considered normal or homoscedastic at values of $P > 0.05$. The potential confounding effects of the incision length, body weight, and inflammation score on GCMP-sf score or serum cortisol concentration were assessed by introducing these variables into the repeated-measures ANOVA model. Variables were deemed to have a confounding effect if the $P$ value of any other variable included in the model switched from significant to nonsignificant or vice versa.

The last step in the analysis was to estimate the correlations between CMPS-sf scores and serum cortisol concentrations by calculation of the Spearman $\rho$ value. Correlation was considered poor if $< 0.30$, mild if $0.31$ to $0.60$, good if $0.61$ to $0.80$, and excellent if $> 0.80$. For all analyses, values of $P < 0.05$ were considered significant.

## Results

### Animals

Forty-six female dogs met initial inclusion criteria for the study; 22 were initially assigned to the TLP group, and 24 were initially assigned to the placebo group. However, in the TLP group, 1 dog was excluded after detection of cardiac arrhythmia before patch application, a second dog was excluded because it had already been spayed, and a third dog was excluded after loose intradermal sutures led to incisional bleeding, necessitating removal of the TLP for wound inspection 8 hours after surgery. In the placebo group, 1 dog was excluded following ingestion of a foreign body, requiring carprofen to be discontinued for gastric protection, and 2 dogs (1 of which had a body wall herniation 16 days after surgery) were excluded because of late blood sample collection. No other complications were observed during the study.

The final TLP group was comprised of 19 dogs, with a mean ± SD body weight of $19.2 \pm 3.2$ kg ($42.2 \pm 7.0$ lb) and mean incision length of $12.8 \pm 2.9$ cm. The final placebo group was comprised of 21 dogs, with a mean ± SD body weight of $21.7 \pm 5.4$ kg ($47.7 \pm 11.9$ lb) and a mean incision length of $12.6 \pm 3.2$ cm. No significant differences were identified between treatment groups with respect to body weight ($P = 0.11$) or incision length ($P = 0.80$). All dogs were of mixed breeding except for 1 Poodle in the TLP group and 1 Bloodhound and 1 pit bull–type dog in the placebo group. Inflammation scores for surgical incisions in both groups ranged from 0 to 6 (median, 1; maximum possible score, 15) and did not differ significantly ($P = 0.57$) between treatment groups. No dogs developed signs of incisional infection.

### CMPS-sf scores

No significant differences were identified between treatment groups in CMPS-sf scores over time ($P = 0.10$) or at any specific assessment point ($P = 0.32$; Figure 1). No confounding effect on CMPS-sf scores at the various assessment points was identified for dog body weight, incision length, or inflammation score at the 3 assessment points. No dog attained a CMPS-sf score indicative that analgesic intervention was required (ie, no dog had a score equal to or greater than 6/24 or 5/20).

### Serum cortisol concentration

No significant or clinically relevant difference was identified between treatment groups in serum cortisol concentrations by calculation of the Spearman $\rho$ value. Correlation was considered poor if $< 0.30$, mild if $0.31$ to $0.60$, good if $0.61$ to $0.80$, and excellent if $> 0.80$. For all analyses, values of $P < 0.05$ were considered significant.

![Figure 1](https://example.com/figure1.png)
concentration over time ($P = 0.08$) or at any specific assessment point ($P = 0.46$; Figure 2). No confounding effect on serum cortisol concentration at the various assessment points was identified for dog body weight, incision length, or inflammation score.

**Correlation between CMPS-sf score and serum cortisol concentration**

Overall, a mild positive correlation was identified between CMPS-sf score and serum cortisol concentration ($\rho = 0.43; P < 0.001$). Serum cortisol concentrations were not necessarily higher at higher CMPS-sf scores. The CMPS-sf scores were generally quite low, and the highest score was 5/24. Eight dogs reached a CMPS-sf score of 5/24 (3 in the TLP group and 5 in the placebo group).

**Discussion**

The present study involving the effects of a TLP on indicators of pain in healthy dogs following ovariohysterectomy revealed no significant or clinically relevant differences in CMPS-sf scores or serum cortisol concentrations between dogs that received the TLP and dogs that received a placebo patch. These findings concur with results of a meta-analysis\(^8\) in human medicine that showed TLP application may not be an effective adjunct for management of severe traumatic and postoperative pain. The TLP is effective in controlling posttherapeutic neuralgia, postsurgical neuropathic pain, posttraumatic neuropathic pain, and pain associated with carpal tunnel syndrome in humans.\(^9,10\) However, neuropathic pain is a distinct phenomenon and it cannot be presumed that the TLP would be useful for other types of pain.

Neuropathic pain is a clinical syndrome characterized by abnormal somatosensory processing in the peripheral nervous system or CNS and serves no beneficial purpose.\(^30\) This type of pain is believed to develop following reorganization of sensory transmission within the nervous system that occurs in response to nerve injury. This reorganization includes changes in the expression of neurotransmitters, neuromodulators, structural proteins, receptors, and ion channels.\(^30\) Specifically, following nerve injury, upregulation of sodium channels occurs at the site of the injury and along the axon, resulting in foci of hypersensitivity.\(^31\) These sodium channels are blocked by local anesthetics, which could be the reason that TLP is so effective in treating neuropathic pain.\(^7\) Indeed, neuropathic pain is a unique disease state, and the efficacy of the TLP in affected patients is not necessarily replicated when the TLP is applied to patients that have just undergone surgery.

The analgesic efficacy of the TLP has been demonstrated in humans with rib fractures.\(^32\) This contrasts with the findings of the aforementioned meta-analysis\(^8\) and the present study, which suggested the TLP is not useful for treatment of somatic pain. However, analgesic efficacy in humans with rib fractures is long term and thus it is possible that a component of neuropathic pain exists in those individuals.\(^32\) The findings of the present study and the meta-analysis are also in contrast to those of a human study\(^33\) in which TLP relieved pain following laparoscopic abdominal surgery. Abdominal wall nerve irritation can occur with fascial closure of laparoscopic incisions, and this is a possible explanation for the effectiveness of the analgesia provided via TLP in humans undergoing laparoscopy.\(^34\)

Severity of postoperative pain could be expected to have been low in both groups in the present study because of concurrent administration of morphine and carprofen, and it is possible that the low level of pain achieved despite those treatments precluded detection of significant differences between groups. Consequently, limited opportunity existed for the TLP to provide analgesia. This represented a limitation of this study and was supported by the fact that no dogs required rescue analgesia. Another possibility is that ovariohysterectomy did not cause enough pain to detect a need for additional analgesia in dogs in the TLP group. This possibility would concur with findings of other studies\(^37,35\) indicating that pain following ovariohysterectomy is only mild to moderate in severity. The TLP may be beneficial in dogs with more severe pain than in the present study. Multimodal analgesia increases the overall analgesic effect by targeting the pain pathway at multiple points, and the TLP may have a role in this approach.\(^1\)

The sample size calculation for the present study was based on data extracted from a previous study\(^15\) with a similar design. Although our sample size was calculated to provide adequate power to find a clinically relevant difference in pain indicators between
the 2 treatment groups, the SDs of the CMPS-sf scores and serum cortisol concentrations (reflected by the 95% confidence intervals in Figures 1 and 2) were generally larger than those reported for the other study.\textsuperscript{15} This difference in SDs may have biased our sample size calculation. Consequently, we remain uncertain whether the lack of differences between the 2 groups was real or simply the result of low statistical power.

High serum cortisol concentration following anesthesia and surgery is part of the typical neuro-humoral stress response, and despite idiosyncratic variations in values, cortisol concentration in biological fluids is widely used as a direct marker of stress and an indirect marker of pain.\textsuperscript{10,23,28} However, the veterinary environment can cause distress for some dogs.\textsuperscript{56} Therefore, dogs in the present study may have had high serum cortisol concentrations without having pain. This effect may have increased data variability and made it more difficult to identify differences between groups in serum cortisol concentration. Our results raise the question of whether cortisol concentration is a good marker of pain intensity in clinical research involving pain assessment in dogs.

Another factor that may have contributed to the high data variability in the present study was the need for indirect measures of level of discomfort in dogs. The CMPS-sf is an observational pain scale and is considered a reliable tool for pain assessment in dogs undergoing a variety of surgical procedures.\textsuperscript{21,22} However, although an intended purpose of the CMPS-sf is to increase observer objectivity, it is possible that fear behaviors could be misinterpreted as discomfort.

A third potential source of high data variability was interobserver differences in CMPS-sf score assignment, which was not evaluated as part of the present study. It was not logistically possible for each observer to perform 18 consecutive hours of observations; therefore, at each assessment point, only 1 observer was randomly assigned to assess all dogs. The total number of observations was divided evenly and was assigned randomly among the 5 observers. To further minimize interobserver variation, training was provided to all observers to standardize use of the CMPS-sf and to confirm that they understood the definitions of all descriptors used in the scoring system. Additionally, the CMPS-sf is a validated pain scale, is considered a reliable clinical tool for postoperative pain assessment in dogs, and was designed to reduce interobserver variation.\textsuperscript{21,22} Despite these efforts, interobserver variation represents an unmeasured factor that could have contributed to data variability in the present study.

Whether pain following ovariohysterectomy originates predominantly from the abdominal wall or visceral manipulation remains unclear.\textsuperscript{37,58} If this pain originates predominantly from viscera, the TLP, which yields minimal systemic absorption of lidocaine, may not be useful in relieving postoperative discomfort.\textsuperscript{11,12} This is an additional potential factor that could explain the failure of the TLP to reduce postoperative pain in the present study.

Another potential confounding factor was that veterinary students performed the surgeries. The less experience a surgeon has, the longer the duration of surgery and anesthesia, the greater the risk of hemorrhage, and the greater the heat loss. Additionally, inexperienced surgeons could cause more tissue trauma than experienced surgeons because of tissue drying, rough tissue handling, longer surgical incisions, and poor instrument handling.\textsuperscript{39} These effects could have affected the CMPS-sf scores and serum cortisol concentrations. Standardization of incision length was attempted; however, comfort of the student surgeons was given precedence, resulting in a range of incision lengths. Regardless of this range, incision lengths did not differ significantly between treatment groups.

Furthermore, most dogs entering the student surgery program at our institution are generally lean, mixed-breed dogs, and body condition score was not recorded. Variation in body condition could have reduced the analgesic effect of the TLP because there would have been greater distance from the skin to the muscles of the body wall. In a study\textsuperscript{40} involving humans, a depth of 8 mm was identified as the maximum mean pain depth observed with a combination lidocaine-tetracaine patch.\textsuperscript{40} In the present study, the TLP was applied 1 cm distal to the wound edge because of its lack of sterility and the lack of information regarding the extent of lidocaine absorption across broken skin. Lidocaine could have penetrated < 1 cm toward the incision site, failing to reach it and therefore affecting analgesic efficacy of the TLP.

During the present study, serum samples were stored for up to 8 months at –62°C, which is a widely accepted temperature for long-term serum storage.\textsuperscript{27} However, stability of cortisol in serum under these conditions is unconfirmed. Cortisol concentration can remain stable for 14 days when serum samples are stored at –6°C.\textsuperscript{41} Storage at –20°C has also been deemed appropriate for biological samples in which measurement of cortisol concentration is expected to occur > 48 hours later.\textsuperscript{26} Additionally, storage at –70°C and –80°C has been used in similar studies involving batch processing for measurement of serum cortisol concentration.\textsuperscript{15,28} Given this range of previously used storage temperatures, the chosen storage conditions were deemed acceptable by the authors. No dogs developed a surgical wound infection during the 48-hour follow-up period in the present study. This result is consistent with findings for humans in which no increase in the rate of wound infection was identified after TLP application.\textsuperscript{8–10,33} Indeed, studies\textsuperscript{42,43} have shown that lidocaine has antibacterial, antifungal, and antiviral effects.\textsuperscript{42,43} No significant difference was identified between treatment groups in the degree of wound inflammation, which is consistent with reported findings for dogs that local reactions to the TLP are mild, infrequent, and transient.\textsuperscript{11,12,20} Furthermore, in vivo and in vitro
research has revealed that topical application of lidocaine has anti-inflammatory and antiedema effects. When assessing surgical wounds for signs of infection and inflammation, the clinical judgment of the observers was relied upon to determine what constituted mild, moderate, and severe erythema, urticaria, edema, warmth, and swelling. These observers included a certified veterinary technician and 4 third-year veterinary students who were considered to have had sufficient clinical judgment to appropriately assess clinical signs. However, lack of specified objectives during these observations created the potential for interobserver variation.

Dogs used in the present study were returned to the shelter or adopted 48 hours after surgery, so long-term wound assessment was not possible. Future research should involve objective and long-term evaluation of wound healing after TLP use in dogs, particularly because there is yet to be a definite conclusion on potentially adverse effects of topical application of local anesthetics on wound healing. Some studies have shown a reduction in collagen formation and tensile strength and a delay in wound healing following topical application of local anesthetics. However, a large body of research has revealed contradictory results, with no difference identified in the tensile strength or healing with topical application of local anesthetics.

In the study reported here, no significant differences in CMPS-sf scores or serum cortisol concentrations were identified between dogs that received a TLP and dogs that received a placebo patch following ovariohysterectomy. The TLP did not appear to increase the risk of surgical wound infection or inflammation, and additional studies are needed to investigate the benefit of the TLP in dogs undergoing ovariohysterectomy with analgesic regimens other than those used in this study.

Acknowledgments

Supported by Morris Animal Foundation (grant No. D15CA-820) and the College of Veterinary Medicine, University of Illinois. None of the authors had a financial or personal relationship with people or organizations that could have inappropriately influenced or biased the content of this paper.

The authors thank Vanessa Cook, Amy Fink, Brigitte Mason, Danielle Rahe, Teresa Schecker, Heather Soder, and Shawn Stevens for technical assistance.

Footnotes


b. Lidocaine patch 5%, Watson Laboratories, Parsippany, NJ.
c. Immulite immunoassay analyzer, Siemens, Brussels, Belgium.
d. STATA, version 14.0, StataCorp LP, College Station, Tex.
e. Rimadyl tablets, Zoetis, Florham Park, NJ.
f. Rimadyl tablets, Zoetis Australia, Rhodes, NSW, Australia.

References

Biomechanical and histologic evaluation of the effects of underwater treadmill exercise on horses with experimentally induced osteoarthritis of a carpal joint

Melissa R. King et al

OBJECTIVE
To evaluate the effects of exercise in an underwater treadmill (UWT) on forelimb biomechanics and articular histologic outcomes in horses with experimentally induced osteoarthritis of a carpal joint.

ANIMALS
16 horses.

PROCEDURES
An osteochondral fragment was induced arthroscopically (day 0) in 1 middle carpal joint of each horse. Beginning on day 15, horses were assigned to exercise in a UWT or in the UWT without water (simulating controlled hand walking) at the same speed, frequency, and duration. Thoracic and pelvic limb ground reaction forces for exercise, thoracic limb kinematics, and electromyographic results for select thoracic limb muscles acting on the carpi were collected on days –7 (baseline), 14, 42, and 70. Weekly evaluations included clinical assessments of lameness, response to carpal joint flexion, and goniometric measurements of thoracic limb articulations. At study conclusion, articular cartilage and synovial membrane from the middle carpal joints was histologically examined.

RESULTS
Exercise in a UWT significantly reduced synovial membrane inflammation and resulted in significant clinical improvements with regard to symmetric thoracic limb loading, uniform activation patterns of select thoracic limb muscles, and return to baseline values for carpal joint flexion, compared with results for horses with simulated hand walking.

CONCLUSIONS AND CLINICAL RELEVANCE
Overall improvements in thoracic limb function, joint range of motion, and synovial membrane integrity indicated that exercise in a UWT was a potentially viable therapeutic option for the management of carpal joint osteoarthritis in horses. (Am J Vet Res 2017;78:558–569)