Use of a continuous, local infusion of bupivacaine for postoperative analgesia in dogs undergoing total ear canal ablation

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Objective—To determine whether addition of a continuous, local infusion of bupivacaine would improve postoperative analgesia in dogs undergoing total ear canal ablation.

Design—Randomized controlled trial.

Animals—16 dogs undergoing total ear canal ablation (12 unilaterally and 4 bilaterally with > 1 month between procedures).

Procedure—Dogs were randomly allocated to receive morphine (0.25 mg/kg [0.11 mg/lb]) at the end of the procedure (10 procedures) or morphine and a continuous, local infusion of bupivacaine (0.13 to 0.21 mg/kg/h [0.06 to 0.1 mg/lb/h]; 10 procedures). Dogs were observed for 48 hours after surgery. Additional doses of morphine were administered up to every 4 hours in dogs with signs of severe pain.

Results—Temperament, sedation, analgesia, and cumulative pain scores were not significantly different between groups any time after surgery. Recovery score was significantly higher for dogs that received bupivacaine than for control dogs 2 hours after extubation but not at any other time. Serum cortisol concentration was not significantly different between groups at any time but, in both groups, was significantly increased at the time of extubation, compared with all other observation times. Total number of additional doses of morphine administered was not significantly different between groups. Bupivacaine was not detected in the plasma of any of the dogs that received the local bupivacaine infusion.

Conclusions and Clinical Relevance—Results suggest that addition of a continuous, local infusion of bupivacaine did not significantly increase the degree of postoperative analgesia in dogs that underwent total ear canal ablation and were given morphine at the end of surgery. (*J Am Vet Med Assoc* 2005;227:414–419)

Many strategies have been developed to relieve postoperative pain and stress and optimize recovery and healing.[1,2] Opioid analgesics have been the mainstay of pain management, but other medications, such as α_2-adrenoceptor agonists, dissociative anesthetics, tranquilizers, nonsteroidal anti-inflammatory drugs, and local anesthetics, have been used to complement opioid treatment.[1,3] Local anesthetics disrupt the generation and transmission of nerve impulses and, thus, more completely interrupt central facilitation of persistent nociceptive nerve stimulation than do systemic analgesics.[2,4-6] The combination of a local anesthetic and a systemic opioid may not only improve pain management but also allow a decrease in the opioid dosage, thereby decreasing the risk of adverse effects associated with opioid administration such as bradycardia, respiratory depression, hypothermia, and sedation.[2-4,6] Local anesthetics have been administered perineurally, epidurally, intrapleurally, intra-articularly, and topically to alleviate pain associated with various surgeries in dogs.[5-7]

Total ear canal ablation (TECA) and **lateral bulla osteotomy (LBO)** typically result in substantial pain in dogs.[8] In a previous study,[8] administration of a single dose of local anesthetic topically or perineurally did not decrease the pain and stress associated with TECA-LBO in dogs. In contrast, continuous infusion of a local anesthetic has been shown in human patients to decrease pain and opioid requirements following a variety of surgical procedures.[9-14] Thus, the purpose of the study reported here was to determine whether addition of a continuous, local infusion of bupivacaine would improve postoperative analgesia in dogs undergoing TECA-LBO and receiving morphine IM.

Materials and Methods

Experimental protocol—Sixteen client-owned dogs scheduled to undergo TECA-LBO at the Kansas State University College of Veterinary Medicine because of chronic otitis externa were enrolled in the study. Twelve dogs had unilateral otitis externa, and 4 dogs had bilateral otitis externa. In the dogs with bilateral otitis externa, TECA-LBO was performed bilaterally with a minimum of 1 month between surgical procedures. For these dogs, each procedure was considered separately. Thus, data were collected for 20 surgical procedures.

Dogs enrolled in the study had not been given any medications topically or systemically for at least 1 week prior to surgery. All dogs received morphine for postoperative analgesia. In addition, after 10 of the procedures, dogs received a continuous, local infusion of bupivacaine at the surgical site. A random numbers table was used to determine which dogs would receive the infusion of bupivacaine. All dogs were monitored for signs of pain after surgery, and additional morphine was administered if signs of severe pain were seen. The experimental protocol was approved by the Kansas State University Institutional Animal Care and Use Committee.

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Preoperative evaluation—Baseline rectal temperature, heart rate, respiratory rate, and plasma glucose concentration were measured prior to surgery. Samples were collected for measurement of serum cortisol concentration at the time of admission and 12 hours later but prior to surgery, and a temperament score[15] ranging from 1 to 5 (**Appendix**) was assigned.

Anesthetic and surgical procedures—Dogs were anesthetized according to the preferences of the attending anesthesiologist, but in general, all dogs were premedicated with diazepam (0.2 mg/kg [0.09 mg/lb], IM or SC) or acepromazine (0.02 to 0.04 mg/kg [0.009 to 0.018 mg/lb], IM or SC) in combination with hydromorphone (0.2 mg/kg, IM or SC), morphine (0.5 mg/kg [0.23 mg/lb], IM or SC), or oxymorphone (0.1 mg/kg [0.045 mg/lb], IM or SC). Dogs were anesthetized with propofol (3 to 5 mg/kg [1.4 to 2.3 mg/lb], IV) or thiopental (10 to 12 mg/kg [4.5 to 5.5 mg/lb], IV), and anesthesia was maintained with isoflurane.

In all but 1 instance, TECA-LBO was performed by a single board-certified veterinary surgeon (MGR). The remaining procedure was performed by a second board-certified veterinary surgeon. In all instances, swab specimens were collected from the tympanic bulla at the end of the procedure and submitted for aerobic and anaerobic culture. A 0.25-inch Penrose drain was placed in the tympanic bulla, and tissue lateral to the bulla was apposed with polydioxanone suture in a cruciate pattern. In dogs randomly selected to receive the continuous, local infusion of bupivacaine, a catheter was placed in the tissues directly overlying these sutures and exited through a stab incision in the skin. This catheter was attached to an elastomeric pump[a] with a total volume of 45 mL that had a delivery rate of 0.5 mL/h. In dogs that weighed ≤ 20 kg (44 lb), the pump was filled with 0.5% bupivacaine, and in dogs that weighed > 20 kg, the pump was filled with 0.75% bupivacaine.

The remaining tissues were closed routinely, and a bandage was applied to the head and neck of all dogs, with the elastomeric pump attached to the outside layer of the bandage. In dogs that did not receive the bupivacaine infusion (control dogs), a sham pump filled with saline (0.9% NaCl) solution was incorporated in the bandage. The pump catheter was attached to a collection bag covered by the bandage so that observers were blinded to treatment group. All dogs were treated with cefazolin (22 mg/kg [10 mg/lb], IV, q 8 h) after surgery.

Postoperative monitoring—Temperament, sedation, recovery, and analgesia scores[15] were assigned by a single observer (RP) blinded to treatment group at the time of extubation and 2, 6, 10, 14, 18, 22, 36, and 48 hours later. At the same times, rectal temperature, heart rate, and respiratory rate were measured and samples were collected for determination of plasma glucose and serum cortisol concentrations. Samples were collected for determination of plasma bupivacaine concentration at time 0, representing the time of extubation, and 6, 18, 36, and 48 hours later.

All dogs were given a single dose of morphine (0.25 mg/kg [0.11 mg/lb], IM) at the time of extubation. Additional doses of morphine (0.25 mg/kg, IM) were given up to every 4 hours after surgery if temperament or analgesia score was ≥ 3, as determined by intensive care unit personnel, or if ordered by the attending surgeon on the basis of behavior and physiologic parameters. Number of morphine doses given following extubation was recorded for each dog.

In dogs that developed adverse reactions (eg, nausea, vomiting, and ataxia) possibly related to the bupivacaine infusion, the catheter was promptly removed and treatment for the adverse reaction was administered. Infusion catheters were removed after 48 hours, and for dogs given bupivacaine, catheter tips were submitted for aerobic and anaerobic culture.

All dogs were treated with antimicrobials for a minimum of 3 weeks after surgery; antimicrobials were selected on the basis of results of bacterial culture and susceptibility testing.

Measurement of plasma bupivacaine concentration—Plasma samples for determination of plasma bupivacaine concentration were stored at –62.2°C until analyzed. Plasma bupivacaine concentrations were measured by a commercial laboratory.[b] Briefly, bupivacaine was extracted from plasma samples with isopropanol in dichloromethane and 1.0M borate buffer. Extracted samples were centrifuged, and the organic layer was transferred to a clean test tube and concentrated by drying under nitrogen. The material was reconstituted with a 2:1 mixture of methanol and ethyl acetate and submitted for gas chromatographic thermoionic specific detection. Calibration standards of 5, 25, 50, 100, and 200 ng/mL were prepared, and a standard curve was constructed. The assay's limit of detection was 50 ng/mL, and the limit of quantification was 100 ng/mL.

Measurement of serum cortisol concentration—Serum samples for determination of serum cortisol concentration were stored at –62.2°C until analyzed. Serum cortisol concentrations were measured by a commercial laboratory[c] with a commercially available assay kit.[d] The assay was a solid-phase chemiluminescent immunoassay. The limit of sensitivity of the assay was 0.2 µg/dL.

Statistical analyses—At each postoperative observation time, a cumulative pain score was calculated by summing the temperament, recovery, and analgesia scores and adding scores for percentage change in rectal temperature, heart rate, and respiratory rate. The cumulative score was increased by 1 if heart rate was > 20% higher than the baseline (ie, preoperative) rate, by 2 if heart rate was > 50% higher than baseline rate, and by 3 if heart rate was > 100% higher than baseline rate. Similarly, the cumulative score was increased by 1 if respiratory rate was > 20% higher than the baseline rate, by 2 if respiratory rate was > 50% higher than baseline rate, and by 3 if respiratory rate was > 100% higher than baseline rate. Finally, the cumulative score was increased by 1 if rectal temperature was > 39.2°C (102.5°F).

Data that were normally distributed were expressed as mean ± SD; data that were not normally distributed were expressed as median and range. Temperament, analgesia, sedation, recovery, and cumulative pain scores were compared between groups at each time period with the Mann-Whitney *U* test and over time within group with the Friedman repeated-measures test followed by the Tukey multiple comparisons procedure. Rectal temperature, heart rate, respiratory rate, plasma glucose concentration, serum cortisol concentration, and plasma bupivacaine concentration were compared between groups at each time period by means of independent *t* tests and over time within group by means of repeated-measures ANOVA followed by the Newman-Keuls procedure. For all analyses, values of $P < 0.05$ were considered significant.

Results

The 16 dogs enrolled in the study consisted of 6 Cocker Spaniels, 3 mixed-breed dogs, 2 Golden Retrievers, 1 Miniature Poodle, 1 Lhasa Apso, 1 Airedale Terrier, 1 Beagle, and 1 Boston Terrier. Mean ± SD weight of control dogs (20.9 ± 12 kg [46 ± 26 lb]) was not significantly different from mean weight of dogs treated with bupivacaine (19.6 ± 11 kg [43 ± 24 lb]). Similarly, mean age of control dogs (7.8 ± 1.5 years) was not significantly different from mean age of dogs treated with bupivacaine (7.3 ± 2.3 years). Dogs with bilateral

otitis externa consisted of 2 Cocker Spaniels, a Golden Retriever, and a mixed-breed dog. In 3 dogs, otitis externa was associated with a ceruminous gland adenocarcinoma of the external ear canal.

Mean duration of surgery, including catheter placement and assessment of flow, was 1.7 ± 0.3 hours. Mean anesthesia time (ie, time from administration of premedications to extubation) for control dogs (247.5 ± 42.9 minutes) was not significantly different from mean anesthesia time for dogs given bupivacaine (259.3 ± 37.1 minutes). Mean infusion rate for dogs receiving bupivacaine was 0.18 ± 0.04 mg/kg/h (0.08 ± 0.018 mg/lb/h; range, 0.13 to 0.21 mg/kg/h [0.06 to 0.1 mg/lb/h]) or 4.3 ± 0.96 mg/kg/d (1.95 ± 0.44 mg/lb/d; range, 3.2 to 5.0 mg/kg/d [1.5 to 2.3 mg/lb/d]).

None of the dogs developed adverse reactions necessitating premature removal of the catheter. Mild facial nerve paresis was identified postoperatively in 2 control dogs and 2 dogs that received bupivacaine.

Temperament, sedation, analgesia, and cumulative pain scores were not significantly different between groups at any observation time (**Table 1**). Recovery score was significantly higher for dogs that received bupivacaine than for control dogs 2 hours after extubation but not at any other observation time. Results of post hoc power analyses of scored data indicated that the number of dogs in each group was sufficient to provide an 80% chance of rejecting the null hypothesis if the true difference between groups was at least 30%.

Changes over time in regard to rectal temperature, heart rate, respiratory rate, plasma glucose concentration, and serum cortisol concentration were similar for the 2 groups. For both groups, rectal temperature was significantly decreased, compared with baseline temperature, from 2 through 48 hours after extubation (Table 1). Rectal temperature was significantly lower for control dogs than for dogs that received bupivacaine 10 and 14 hours after extubation but not at other observation times. For control dogs, heart rate was significantly increased at the time of extubation, compared with all other observation times. Serum cortisol concentration was not significantly different between groups at any time but, in both groups, was significantly increased at the time of extubation, compared with all other observation times. Plasma glucose concentration was not significantly different between groups at any time, but in control dogs, plasma glucose concentration was significantly higher at the time of extubation than it was 48 hours later.

Total number of additional doses of morphine administered was not significantly different between groups. Four control dogs and 1 dog that received bupivacaine were given additional doses of morphine. Three of the 4 control dogs that received additional doses of morphine received 2 additional doses, and the

Table 1—Physiologic measurements and pain scores in 16 dogs undergoing total ear canal ablation (12 unilaterally and 4 bilaterally with > 1 month between procedures) that were randomly allocated to receive morphine (0.25 mg/kg [0.11 mg/lb]) at the end of the procedure (10 procedures; control group) or morphine and a continuous, local infusion of bupivacaine (0.13 to 0.21 mg/kg/h [0.06 to 0.1 mg/lb/h]; 10 procedures).

			Time after extubation (h)								
Variable	**Group**	**Baseline**	**0**	**2**	**6**	**10**	**14**	**18**	**22**	**36**	**48**
Rectal temperature (°C)	Control	38.7 ± 0.4	35.7 ± 0.9	38.1 ± 0.4*	38.8 ± 0.4*	38.6 ± 0.8*†	38.8 ± 0.3*†	38.9 ± 0.3*	38.7 ± 0.6*	38.9 ± 0.4*	38.9 ± 0.4*
	Bupivacaine	38.8 ± 0.4	36.6 ± 1.2	38.2 ± 0.8*	38.9 ± 0.5*	39.2 ± 0.4*†	39.2 ± 0.3*†	39.2 ± 0.5*	39.4 ± 0.7*	39.1 ± 0.4*	39.0 ± 0.5*
Heart rate (beats/min)	Control	110 ± 14	128 ± 48‡	85 ± 20	87 ± 15	89 ± 14	88 ± 9	100 ± 17	95.2 ± 9	99 ± 12	98 ± 9
	Bupivacaine	107 ± 25	107 ± 38	88 ± 20	82 ± 24	90 ± 28	96 ± 29	101 ± 29	102 ± 26	102 ± 25	95 ± 17
Respiratory rate (breaths/min)	Control	37.6 ± 13	28.0 ± 18	30.4 ± 16	38.7 ± 19	32.6 ± 11	30.6 ± 13	33.7 ± 15	39.6 ± 18	38.4 ± 20	36.7 ± 14
	Bupivacaine	34.7 ± 8	23.0 ± 16	37.3 ± 18	37.3 ± 12	39.1 ± 13	24.4 ± 14	42.6 ± 14	38.0 ± 13	38.4 ± 14	42.6 ± 11
Plasma glucose (mg/dL)	Control	104 ± 13	138 ± 32§	127 ± 21	114 ± 26	118 ± 19	124 ± 38	124 ± 35	130 ± 32	115 ± 20	106 ± 25
	Bupivacaine	96 ± 9	135 ± 35	133 ± 26	109 ± 16	117 ± 15	117 ± 18	110 ± 23	107 ± 25	110 ± 15	109 ± 10
Serum cortisol (mg/dL)	Control	2.62 ± 1.4	5.50 ± 2.5‡	4.66 ± 1.4‖	2.14 ± 1.1	2.68 ± 1.9	2.61 ± 1.9	2.63 ± 1.0	2.40 ± 1.5	2.47 ± 1.6	1.97 ± 0.7
	Bupivacaine	3.02 ± 1.9	6.30 ± 2.0‡	4.64 ± 3.8	2.57 ± 1.8	3.74 ± 2.4	3.32 ± 1.8	2.91 ± 2.0	3.05 ± 2.8	2.44 ± 2.0	2.40 ± 2.0
Cumulative pain score	Control	NA	8.5 (7–18)	7.5 (7–9)	6 (4–14)	5 (4–8)	4 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)	4 (4–5)
	Bupivacaine	NA	8 (8–16)	7 (6–19)	5 (4–12)	4 (4–12)	4 (4–7)	4 (4–6)	4.5 (4–8)	4 (4–5)	4 (4)
Temperament score	Control	1 (1–3)	1 (1–5)	1 (1–3)	1.5 (1–2)	1.5 (1–2)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1)
	Bupivacaine	1 (1–3)	1 (1–4)	1 (1–4)	1 (1–3)	1.5 (1–5)	1 (1–4)	1 (1–3)	1 (1)	1 (1)	1 (1–2)
Sedation score	Control	NA	4.5 (2–5)	3 (2–5)	2 (1–5)	1 (1–2)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
	Bupivacaine	NA	5 (2–5)	3 (1–5)	2 (1–2)	1 (1–3)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1–2)	1 (1)
Recovery score	Control	NA	2.5 (3–5)	1† (1–2)	1 (1–5)	1 (1–2)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
	Bupivacaine	NA	2 (1–5)	2† (1–4)	1 (1–2)	1 (1–2)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
Analgesia score	Control	NA	1 (1–5)	1 (1–2)	1 (1–4)	1 (1–2)	1 (1–2)	1 (1)	1 (1)	1 (1)	1 (1)
	Bupivacaine	NA	1 (1–5)	1 (1–4)	1 (1–2)	1 (1–5)	1 (1)	1 (1–2)	1 (1)	1 (1)	1 (1)

Data are given as mean ± SD or median (range). Possible temperament, sedation, recovery, and analgesia scores ranged from 1 to 5. Possible cumulative pain score ranged from 3 to 27.

*Value was significantly ($P < 0.05$) different from value obtained at the time of extubation. †Values were significantly ($P < 0.05$) different between groups at this time. ‡Value was significantly ($P < 0.05$) different from values obtained at all other observation times for this group. §Value was significantly ($P < 0.05$) different from value obtained 48 hours after extubation for this group. ‖Value was significantly ($P < 0.05$) different from baseline value for this group.

NA = Not applicable.

remaining dog received a single additional dose. The dog that received bupivacaine was given a single additional dose of morphine; however, the intensive care unit attendant caring for this dog reported at other times that the dog seemed painful but did not administer additional doses of morphine. Cumulative pain scores for this dog were 2, 4, and 1 point higher than the median score for the control group 2, 6, and 10 hours, respectively, after extubation, but at no time were the temperament or analgesia scores ≥ 3.

Bupivacaine was not detected in the plasma of any of the dogs that received the local bupivacaine infusion.

For all dogs, results of bacterial culture of swab specimens obtained from the tympanic bulla at the time of surgery were positive. Bacteria that were isolated included *Escherichia coli* (n = 6), *Proteus mirabilis* (6), *Pseudomonas aeruginosa* (3), *Staphylococcus intermedius* (3), *Staphylococcus epidermidis* (2), β-hemolytic *Streptococcus* spp (2), α-hemolytic *Streptococcus* spp (2), *Streptococcus canis* (2), *Streptococcus* spp (1), *Micrococcus* spp (1), *Actinomyces* spp (1), and *Enterococcus* spp (2). For 1 dog that received bupivacaine, results of bacterial culture of the catheter tip were positive. *Enterococcus faecalis* was cultured from the catheter tip from this dog (*P mirabilis* was cultured from the tympanic bulla swab specimen). For 7 catheter tips, results of bacterial culture were negative. The remaining 2 catheter tips were not submitted for bacterial culture. The dog for which results of bacterial culture of the catheter tip were positive was monitored, and no complications were reported.

Discussion

Results of the present study suggest that the addition of a continuous, local infusion of bupivacaine did not improve postoperative analgesia in dogs that underwent TECA-LBO and were given morphine at the end of surgery. Significant differences in analgesia, sedation, temperament, and cumulative pain scores were not identified between dogs given morphine alone and dogs given morphine and a continuous bupivacaine infusion, suggesting that there was no difference in degree of analgesia between groups. However, despite the lack of significant differences, we believe that a benefit may have existed. It is possible that we did not detect a significant effect of bupivacaine because of the drug's long onset of action. However, the infusion catheter was placed and the bupivacaine infusion was begun before the surgical site was closed, which exceeded 20 minutes in all cases. This time lapse should have allowed sufficient time for the onset of action of bupivacaine.[3]

Similarly, the lack of a significant effect could have been attributable to an inadequate dosage of bupivacaine. The pump delivered bupivacaine at a rate of 0.5 mL/h, so that cumulative dosage during the first 24 hours was 60 mg in dogs weighing ≤ 20 kg and 90 mg in dogs weighing > 20 kg, and mean ± SD bupivacaine dosage was 0.18 ± 0.04 mg/kg/h or 4.3 ± 0.96 mg/kg/d. Although there are no studies on the dosage of bupivacaine given by continuous, local infusion that will result in analgesia in dogs, dosages in the present study were in the range of dosages reported to be effective in studies of continuous epidural administration of bupivacaine in dogs[16] and continuous epidural or extrapleural administration in people.[17,18] For instance, an infusion rate of 0.1 to 0.4 mg/kg/h (0.045 to 0.18 mg/lb/h), not to exceed 4 mg/kg/d (1.8 mg/lb/d), has been recommended for continuous epidural administration of bupivacaine in dogs.[16] Although the pharmacokinetics and pharmacodynamics of local anesthetics following administration in the epidural space probably differ from those obtained following local infusion, this dosage range seemed like a reasonable initial choice for infusions used in the present study. In people, extrapleural infusion of bupivacaine (0.25 mg/kg/h [0.11 mg/lb/h]) for 72 hours after thoracotomy provided effective pain relief, as determined by decreases in postoperative requirement for opioids and pain scores and improvements in pulmonary function.[17] In human infants, it is recommended that the rate of continuous epidural infusion of bupivacaine not exceed 0.25 to 0.3 mg/kg/h (0.11 to 0.14 mg/lb/h).[18]

We did not detect bupivacaine in plasma from any of the dogs in the present study that received the bupivacaine infusion, suggesting that the risk of systemic toxicoses with this protocol was low. However, these findings may also support the suggestion that a higher infusion rate was necessary to provide additive analgesia in these patients.

It is possible that an analgesic effect associated with bupivacaine infusion was not apparent in the present study because the bupivacaine that was administered had only a localized effect. The pump was attached to a single instillation catheter, and the effect of bupivacaine was likely dependent on local spread of the agent.[19] Given the large number of tissue planes that are incised during TECA-LBO, it is possible that penetration of bupivacaine was inadequate. Infusion of a larger volume may have increased tissue penetration; however, infusion of large fluid volumes may affect wound healing.

Local inflammation and infection can diminish the effect of local anesthetics,[20,21] and whether surgical inflammation or residual infection diminished the effectiveness of bupivacaine in the present study could not be determined. However, local anesthetics have been effective following surgery in people.[9,13]

Severity of pain is difficult to assess objectively in animals. A single blinded observer was used to assign scores in an effort to eliminate interobserver variations,[22-25] and scoring systems were similar to those used in previous studies.[15,22] However, these pain scoring systems have been validated only in healthy animals undergoing elective surgery (ovariohysterectomy or onychectomy). Dogs undergoing TECA-LBO in the present study were different in that they were undergoing surgery because of a disease (chronic otitis externa) that has itself been associated with chronic pain. Animals with chronic pain may manifest different behavioral characteristics than animals with acute pain. For instance, a study[26] evaluating pain in dogs with chronic osteoarthritis showed a poor correlation between veterinarian-assigned pain scores and results of an owner questionnaire. It was suggested that owners of dogs with chronic pain conditions have a better ability to rec-

ognize subtle behavioral changes indicative of pain.[26] Chronic pain may also be associated with substantial physiologic changes that alter the efficacy of drugs traditionally used to manage acute surgical pain.[27,28]

It is possible that we did not detect differences in scores between groups in the present study because the level of analgesia was insufficient in both groups of dogs. A single dose of morphine (0.25 mg/kg, IM) was administered to all dogs, with additional doses to be administered if signs of severe pain were seen. Surprisingly, additional doses of morphine were administered after only 5 of 20 procedures in the present study, even though we had anticipated a higher incidence of rescue analgesia, given that TECA-LBO is considered a major surgery associated with substantial postoperative pain. Morphine is an effective analgesic in dogs, but in this study, a midrange morphine dose was chosen to provide analgesia.[29] Although morphine alone may have provided adequate analgesia, we believe that the low incidence of rescue analgesia may be a further indication of the insensitivity of current pain scoring methods for evaluating chronic pain in clinical patients.

A variety of anesthetic protocols were used in the present study, but these protocols mirrored the variations in anesthetic protocol expected in a clinical population. It is difficult to determine what effect, if any, the various premedications and anesthetic induction agents may have had on results of the present study. Most dogs were moved to the recovery area > 4 hours after premedications were administered, so there should have been little residual effect.[30-33] The anesthetic induction agents that were used—thiopental and propofol—are both rapid-acting, short-duration agents that should also have had few residual effects.

In the present study, the only differences between groups were a slightly lower rectal temperature 10 and 14 hours after extubation in control dogs, compared with dogs given bupivacaine, and a slightly higher recovery score 2 hours after extubation in dogs given bupivacaine, compared with control dogs. It is possible that rectal temperature was slightly lower in control dogs because of administration of additional doses of morphine, in that opioids can cause hypothermia.[3] Alternatively, it is possible that infusion of bupivacaine resulted in increased inflammation at the surgical site, which in turn resulted in a slight increase in rectal temperature. However, no wound complications that could be attributed to increased inflammation were seen in dogs given bupivacaine.

The optimal concentration and infusion rate may be higher than those evaluated in the present study, as bupivacaine was not detected in the plasma of any dog. A conservative concentration of bupivacaine and pump with a low infusion rate were chosen because of the close proximity of the infusion catheter to the vestibular and cochlear windows following LBO. Pumps with higher infusion rates are available, and a higher concentration of bupivacaine could be used in future trials.

A possible complication associated with continuous, local infusion of bupivacaine in a surgical site is potentiation of infection. In the present study, no clinical signs were seen that would have suggested complications associated with the infusion system or local administration of bupivacaine. The positive bacterial culture results for 1 catheter tip may have been a result of contamination from the patient or hospital, as clinical signs of infection were not apparent at any time after surgery in this dog. Care should be taken to maintain aseptic technique when placing and working with the infusion system to avoid iatrogenic contamination and infection. The reservoir was filled only once, and the system remained closed for the entire 48-hour study period. Aseptic technique was used during bandage changes in all dogs. Bandages maintained blinding of the observer but also decreased environmental contamination of the catheter and decreased the risk of patient trauma to the catheter and catheter site.

a. On-Q Pain Management System, I-Flow Corp, Lake Forest, Calif.
b. Toxicology Associates Inc, Columbus, Ohio.
c. Idexx Laboratory, Dallas, Tex.
d. Diagnostic Products Corp, Los Angeles, Calif.

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Appendix

Scoring systems used to determine whether addition of a continuous, local infusion of bupivacaine would improve postoperative analgesia in dogs undergoing total ear canal ablation and receiving morphine IM. (Adapted from Carroll GL, Howe LB, Slater MR, et al. Evaluation of analgesia provided by postoperative administration of butorphanol to cats undergoing onychectomy. *J Am Vet Med Assoc* 1998;213:246–250.)

Temperament score
1—Friendly; approaches front of cage when door is opened; relaxed attitude.
2—Friendly; may approach front of cage when door is opened; slightly cautious in interaction with observer; may warm to observer with time.
3—Confident but not friendly; walks in cage; will return to back of cage if handled; no overt aggression shown; may try to escape.
4—Mildly aggressive; does not approach but will allow observer to handle with mild resistance; may growl.
5—Outwardly aggressive; does not approach; may growl or bite; pupils dilated; cannot be handled without protection and restraint.

Sedation score
1—Fully alert; no motor or sensory deficits; similar to preanesthetic state.
2—Faintly sedate; stands and walks; subtle sensory or motor deficits; slight ataxia or disorientation.
3—Mildly sedate; maintains sternal recumbency but does not stand or struggles to stand.
4—Moderately sedate; does not maintain sternal recumbency; can raise head but cannot hold it up.
5—Very sedate; generally unresponsive; unable to raise head.

Recovery score
1—Extubation with easy transition to alertness; quiet until coordinated movements are possible.
2—Fair transition to alertness; short period of disorientation; holds head up; generally quiet.
3—Substantial period of disorientation; some coordinated movement; does not startle; generally quiet.
4—Disoriented with some emergence delirium; limited muscle control; startles; may paddle or whine.
5—Extreme emergence delirium; uncoordinated whole body movements; startles; difficult to restrain.

Analgesia score
1—No signs of pain; moves head and neck freely; no signs of pain during palpation of the surgery site.
2—Signs of slight pain; near-normal head carriage and movement of head and neck; orients to surgery site during palpation but does not resent palpation.
3—Signs of mild pain; restricted movement of head and neck; orients to surgery site and resists palpation.
4—Signs of moderate pain; guarded stance with back arched and neck extended; unwilling to move head and neck; withdraws from palpation of surgery site; vocalizes during palpation but responds to comforting.
5—Signs of severe pain; tense, shivering, rigid, and unwilling to move; avoids touch; may growl or bite; paws at bandage; no response to comforting.