Evaluation of gastric emptying time, gastrointestinal transit time, sedation score, and nausea score associated with intravenous constant rate infusion of lidocaine hydrochloride in clinically normal dogs

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OBJECTIVE
To quantify nausea and sedation scores, gastric emptying time, and gastrointestinal transit time after IV administration of a lidocaine hydrochloride bolus followed by a constant rate infusion (CRI) in clinically normal dogs.

ANIMALS
6 Beagles.

PROCEDURES
In a crossover study, dogs were fed thirty 1.5-mm barium-impregnated spheres (BIPS) and received a saline (0.9% NaCl) solution bolus (0.05 mL/kg) IV (time 0) followed by a CRI at 10 mL/h, a lidocaine bolus (1 mg/kg) IV followed by a CRI at 25 μg/kg/min, or a lidocaine bolus (1 mg/kg) IV followed by a CRI at 50 μg/kg/min; CRIs were for 12 hours. Nausea and sedation scores were assessed and abdominal radiographs obtained immediately after feeding of BIPS and every hour for 12 hours and again 16 hours after CRI start. Percentage of BIPSs in the small and large intestines, gastric emptying time, and gastrointestinal transit time were assessed.

RESULTS
Gastric emptying time did not differ significantly among treatments. Significantly more BIPS were in the large intestine 4 to 7 hours after treatment start for the 50-μg/kg/min treatment than for the other 2 treatments. Six hours after treatment start, significantly more BIPS were in the large intestine for the 25-μg/kg/min treatment than for the saline solution treatment. Higher sedation and nausea scores were associated with the 50-μg/kg/min CRI.

CONCLUSIONS AND CLINICAL RELEVANCE
In clinically normal dogs, lidocaine CRI did not significantly affect gastric emptying. However, gastrointestinal transit time was mildly decreased and sedation and nausea scores increased in dogs administered a lidocaine CRI at clinically used doses. (*Am J Vet Res* 2017;78:550–557)

Lidocaine, a commonly used amide local anesthetic agent, completely blocks sodium channel–mediated generation and conduction of action potentials along nerves,[1] which makes it extremely useful for many local or regional anesthetic techniques. Because nociceptive (and motor) transmission is inhibited with local or regional administration of lidocaine, the amount of inhalation anesthetic required during painful procedures is markedly reduced along with inhalation-associated adverse effects such as hypotension and hypoventilation.[2–5] Thus, local anesthetic techniques that incorporate lidocaine play an integral part in balanced anesthetic and postanesthetic protocols.

Lidocaine is also efficacious when administered IV. For example, IV administration of lidocaine, a class 1B antiarrhythmic, is commonly used to treat ventricular arrhythmias in patients by stabilizing membranes as well as decreasing phase 0 depolarization of the cardiac action potential.[6] Similar to local or regional application, IV administration of lidocaine also has analgesic and antihyperalgesic properties mediated through sodium channel blockade as well as inhibition at G-coupled–protein and *N*-methyl-D-aspartate receptors.[7–10] In dogs, rats, and horses, CRIs of lidocaine reduce nociceptive transmission and the opioid dose required for maintaining analgesia.[11–13] In addition, lidocaine CRIs are commonly used to reduce the minimum alveolar concentration of inhalation anesthetics for dogs,[14] horses,[15,16] cats,[17] calves,[18] and goats.[19] Thus, the use of lidocaine CRIs in veterinary practice is becoming more common for many painful procedures, including ovariohysterectomies, ophthalmic procedures, and orthopedic surgeries.[20–23]

ABBREVIATIONS

BIPS	Barium-impregnated spheres
CRI	Constant rate infusion

Lidocaine has been administered IV to provide analgesia and reduce hyperalgesia in humans and other animals. Lidocaine has also been administered IV to people to decrease the duration of ileus and reduce signs of nausea and vomiting following surgery.[24,25] Similarly, IV administration of lidocaine to horses improves analgesia and reduces postoperative ileus.[26,27] Improvements in intestinal motility associated with lidocaine CRIs most likely are the result of decreases in the amount of opioids required for postoperative analgesia or hyperalgesia, visceral inflammation secondary to surgery, and postoperative stimulation of the sympathetic nervous system.[24,28–31] Although the beneficial effects of lidocaine on intestinal motility have been described in horses[26,27] and humans,[24,25] it is unknown whether similar effects occur in dogs administered lidocaine CRIs at clinically relevant doses.

Radiopaque markers have been used to quantify gastrointestinal motility in dogs,[32–34] cats,[35–37] and horses.[38] Passage of 1.5-mm BIPS in dogs correlates well with passage of a test meal and can be used to radiographically quantify gastric emptying and small intestinal motility. Standardized radiographic methods to assess gastrointestinal transit times in medium-sized dogs fed common kibble diets have been established.[33,34,39]

The purpose of the study reported here was to use 1.5-mm BIPS to quantify gastric emptying time and gastrointestinal transit time in healthy adult Beagles after IV administration of a bolus followed by a CRI for 12 hours of saline (0.9% NaCl) solution or 2 doses of lidocaine. We hypothesized that in conscious healthy dogs, lidocaine CRIs would enhance gastric emptying and decrease gastrointestinal transit time in a dose-dependent manner, compared with results for a saline solution CRI.

Materials and Methods

Animals

Six healthy young adult (< 1 year) Beagles were used in the study. Mean ± SD body weight of the dogs was 10.9 ± 0.4 kg. Dogs were deemed healthy on the basis that no abnormalities were detected during a physical examination, there were no clinical signs of gastrointestinal tract disease, and PCV and total protein concentration were within reference limits. All procedures were approved by the University of Wisconsin School of Veterinary Medicine Animal Care and Use Committee.

Experimental procedures

A randomized, blinded, crossover study was conducted. Dogs were allowed to become acclimated to the radiographic equipment and positioning twice daily for 3 days prior to the start of the study.

Food was withheld from dogs for 24 hours before each experiment. A 22-gauge, 1-inch catheter[a] was placed in a cephalic vein. Dogs were then fed a kibble ration (0.5 resting energy requirements = 0.5 × 70 × [body weight in kg]$^{0.75}$) and thirty 1.5-mm (outer diameter) BIPS[b] mixed in a small amount of baby food.[34] Within 5 minutes after dogs were fed, ventrodorsal, right lateral, and left lateral abdominal radiographs were obtained (baseline), and treatments were started.

Three treatments were administered to the dogs. Treatments consisted of IV administration of a bolus of saline solution[c] (0.05 mL/kg) followed by a saline solution CRI at a rate of 10 mL/h for 12 hours (control treatment), IV administration of a bolus of lidocaine hydrochloride[d] (1 mg/kg [0.05 mL/kg]) followed by a lidocaine CRI at a rate of 25 µg/kg/min for 12 hours, and IV administration of a bolus of lidocaine (1 mg/kg [0.05 mL/kg]) followed by a lidocaine CRI at a rate of 50 µg/kg/min for 12 hours. Lidocaine concentration in the solution was adjusted on the basis of body weight and diluted with saline solution so that a total volume of 10 mL/h was administered for all treatments. For the control treatment, saline solution was administered as a bolus of 0.05 mL/kg to match the bolus volume for administration of lidocaine. The IV administration of a bolus was designated as time 0 (baseline). Each dog received each of the 3 treatments; there was a washout period of ≥ 7 days between successive treatments.

Three-view abdominal radiographs were obtained during each CRI every hour for 12 hours and again at 16 hours.[34] Nausea score (scale, 0 to 4) and sedation score (scale, 0 to 5) were recorded at the same time points; scoring was conducted in accordance with previously established scoring systems[40,41] **(Appendix)**.

Gastric emptying time and gastrointestinal transit time were determined by use of radiographs obtained at each time point by assessment of the location and number of BIPS in the stomach, small intestine, or large intestine.[34] For the purposes of the present study, BIPS that had passed distal to the ileum were counted as in the large intestine, which included all BIPS seen in the cecum, colon, and rectum. For cases in which the location of BIPs was uncertain because of superimposition of intestines and the stomach on radiographs, a conservative selection was made so that only BIPS located definitively in the stomach were counted. The percentage of BIPS in each location at each time point was calculated. Additionally, the times for BIPS to leave the stomach (gastric emptying time) or reach the large intestine (gastrointestinal transit time) were determined on a percentage basis (ie, the time at which 25%, 50%, 75%, and 90% of BIPS had left the stomach or reached the large intestine). Time for each event was recorded to the next highest hour because of the frequency of radiographic imaging.

The investigator responsible for assessing the location of BIPS (BGJ) was unaware of the treatment and time point for each radiograph, and the investigator performing sedation and nausea scoring (KRK) was unaware of the treatment administered to each dog.

Statistical analysis

Statistical analyses were performed by use of 2-way repeated-measures ANOVAs and Student-Newman-Keuls post hoc tests. The Shapiro-Wilk test was used to assess normality of the data; data were logarithmically transformed (when necessary) for analyses (gastric emptying time and gastrointestinal transit time). Time, treatment, and the time-by-treatment interaction were factors for analyses of BIPS found distal to the stomach and in the large intestine. Time, treatment, and the time-by-treatment interaction were also variables for analyses of nausea and sedation scores. Percentage of BIPS (25%, 50%, 75%, and 90%), treatment, and the percentage of BIPS-by-treatment interaction were factors for analyses of gastric emptying time and gastrointestinal transit time.

Data were reported as mean ± SEM. Statistical analyses were performed by use of commercial software.[e] Results were considered significant at $P < 0.05$.

Results

Animals

The BIPS were easily visualized on radiographs obtained from all dogs for all treatments and could be tracked throughout the intestines **(Figure 1)**. All dogs vomited after treatment with a lidocaine CRI at 50 µg/kg/min, and 1 dog was removed from the study after 5 hours of treatment with a lidocaine CRI at 50 µg/kg/min because of excessive vomiting that consisted of 7 episodes during hours 1 to 4 and 11 episodes during the first 15 minutes of hour 5. Exclusion of this dog resulted in a sample size of 5 for the 50-µg/kg/min treatment.

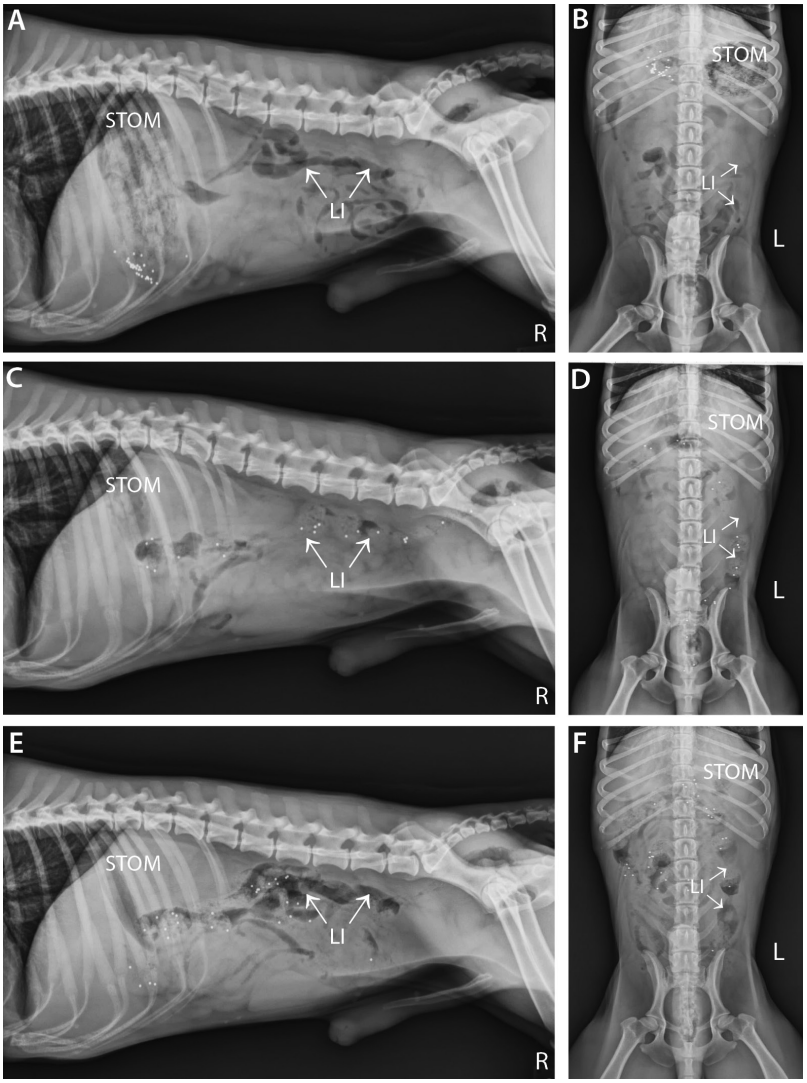

Figure 1—Representative right lateral (A, C, and E) and ventrodorsal (B, D, and F) abdominal radiographic images of a clinically normal dog fed a meal containing thirty 1.5-mm (outer diameter) BIPS that then received a bolus injection (time 0 [baseline]) followed by a CRI of saline (0.9% NaCl) solution or lidocaine (25 and 50 µg/kg/min) for 12 hours. Images were obtained immediately before IV administration of a bolus (A and B) and at 9 hours (C through F). At baseline, notice that all 30 BIPS are already located in the pyloric antrum, whereas most of the food is in the fundus of the stomach (STOM; A and B). After receiving a lidocaine CRI at a rate of 50 µg/kg/min for 9 hours, only 21 BIPS remain because of vomiting (all dogs vomited after the 50 µg/kg/min treatment; C and D). Notice that all 21 BIPS are linearly arranged throughout portions of the large intestine (LI). In contrast, all 30 BIPS are still evident in dogs at 9 hours after the saline solution treatment, and many are located within the small intestine (E and F). L = Left. R = Right.

Gastric emptying time

Compared with the baseline value, significantly more BIPS were found distal to the stomach from 1 to 16 hours after the start of treatment **(Figure 2)**. However, there were no significant differences among treatments in the percentage of BIPS emptied from the stomach and no significant interactions between the independent variables of time and treatment.

Similarly, no significant differences among treatments were detected for gastric emptying times for 25%, 50%, 75%, and 90% of BIPS **(Table 1)**. However, significant time effects were detected when all treatments were combined; gastric emptying times for percentage of BIPS differed significantly from each other, except for the comparison between 75% and 90%.

Gastrointestinal transit time

Significant ($P < 0.001$) interactions were detected between time and treatment for the percentage of BIPS found in the large intestine (Figure 2). Compared with baseline values, significantly more BIPS were found in the large intestine from 7 to 16 hours (control treatment), 6 to 16 hours (treatment with a lidocaine CRI at 25 µg/kg/min), and 4 to 16 hours (treatment with a lidocaine CRI at 50 µg/kg/min). There

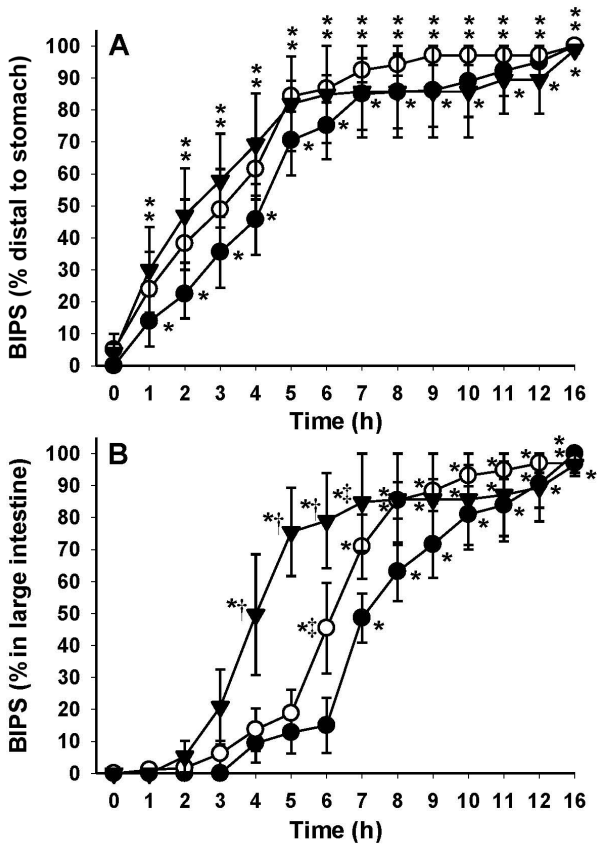

Figure 2—Percentage of BIPS found distal to the stomach (A) and in the large intestine (B) over time for clinically normal dogs fed a meal containing 30 BIPS that then received a bolus injection followed by a CRI of saline solution or lidocaine hydrochloride for 12 hours. Treatments consisted of IV administration of a bolus of saline solution (0.05 mL/kg) followed by a saline solution CRI at a rate of 10 mL/h for 12 hours (control treatment [black circles]), IV administration of a bolus of lidocaine (1 mg/kg [0.05 mL/kg]) followed by a lidocaine CRI at a rate of 25 µg/kg/min for 12 hours (white circles), and IV administration of a bolus of lidocaine (1 mg/kg [0.05 mL/kg]) followed by a lidocaine CRI at a rate of 50 µg/kg/min for 12 hours (black triangles). There were 6 dogs/treatment, except there were only 5 dogs for the 50-µg/kg/min treatment because 1 dog was excluded owing to excessive vomiting. The IV administration of a bolus was designated as time 0 (baseline). *Within a treatment, value differs significantly ($P < 0.05$) from the baseline value. †Within a time point, value differs significantly ($P < 0.05$) from the values for the 25-µg/kg/min and saline solution treatments. ‡Within a time point, value differs significantly ($P < 0.05$) from the saline solution treatment.

were significantly more BIPS found in the large intestine from 4 to 6 hours for the 50-µg/kg/min treatment, compared with results for both the 25-µg/kg/min treatment and control treatment. There were significantly fewer BIPS in the large intestine of the control group, compared with results for the 50-µg/kg/min treatment at 7 hours and with the 25-µg/kg/min treatment at 6 hours.

Although there was a pattern whereby the gastrointestinal transit time was shorter for the 50-µg/kg/min treatment, there were no significant differences among treatments in gastrointestinal transit times for 25%, 50%, 75%, and 90% of BIPS to reach the large intestine (Table 1). However, when all treatments were combined, gastrointestinal transit times for percentage of BIPS differed significantly from each other, except for the comparison between 75% and 90%.

Sedation and nausea scores

Sedation scores differed significantly among time points ($P = 0.027$) and treatments ($P < 0.001$); however, there were no significant time-by-treatment interactions **(Figure 3)**. When all time points were considered, sedation scores were significantly higher for the 50-µg/kg/min treatment than for the 25-µg/kg/min treatment ($P = 0.023$) and control treatment ($P = 0.035$). Compared with baseline values, sedation scores for all 3 treatments were significantly higher between 4 and 6 and at 8 hours.

Significant ($P < 0.001$) interactions were found between time and treatment for nausea scores (Figure 3). At 4 and 5 hours and again at 11 and 12 hours after the start of treatment, nausea scores were significantly higher for the 50-µg/kg/min treatment than for the 25-µg/kg/min treatment and control treatment; nausea scores for the 25-µg/kg/min treatment and control treatment did not differ significantly at any time point.

Discussion

Results for the study reported here suggested that lidocaine administered at the doses used in the present study did not significantly affect gastric emptying times in clinically normal dogs. When dogs were treated by administration of a lidocaine CRI at a rate of 50 µg/kg/min for 12 hours, gastrointestinal transit times were decreased 4 to 7 hours after the start of the treatment because significantly more BIPS were found in the large intestine at that time, compared with results for the saline solution treatment. However, there were no significant differences among treatments in mean times for 25%, 50%, 75%, and 90% of BIPs to reach the large intestine, although the times typically were shorter (but not significantly so) for the 50-µg/kg/min treatment than for the saline solution treatment. In addition, sedation scores differed significantly (primarily at 4 to 6 hours and again at 8 hours after start of treatment), compared with baseline values. The lidocaine CRI at 50 µg/kg/min was also associated with significant differences in nausea scores during treatment, specifically at 4 and 5 hours and again at 11 and 12 hours after the start of treatment. These potentially unwanted adverse effects of sedation and signs of nausea for a lidocaine CRI at 50 µg/kg/min may preclude its use in clinically normal dogs. They may also preclude its use in dogs in which sedation or signs of nausea (or both) may be undesirable, despite the fact those dogs could receive positive benefits that may come from decreased gastrointestinal transit times. However, further testing of lidocaine CRIs in clinical patients is needed to confirm these findings.

Radiopaque markers have been used to determine gastrointestinal tract motility in veterinary

Table 1—Mean ± SD gastric emptying time and gastrointestinal transit time for 6 clinically normal dogs fed a meal containing thirty 1.5-mm (outer diameter) BIPS that then received a bolus injection of saline (0.9% NaCl) solution or lidocaine followed by a CRI of saline solution or lidocaine (25 and 50 µg/kg/min) for 12 hours.

		Percentage of BIPS			
Variable	**Treatment***	**25%**	**50%**	**75%**	**90%**
Gastric emptying time (h)	Saline solution	3.2 ± 0.8[a]	5.2 ± 1.3[b]	7.0 ± 1.9[c]	8.3 ± 1.7[c]
	Lidocaine CRI				
	25 µg/kg/min	2.2 ± 0.7[a]	3.0 ± 0.7[b]	5.2 ± 0.7[c]	7.0 ± 1.9[c]
	50 µg/kg/min†	3.0 ± 1.1[a]	5.2 ± 2.8[b]	6.0 ± 2.5[c]	6.4 ± 2.5[c]
Gastrointestinal transit time (h)	Saline solution	6.0 ± 0.6[a]	8.2 ± 0.8[b]	10.5 ± 1.2[c]	11.0 ± 1.1[c]
	Lidocaine CRI				
	25 µg/kg/min	5.7 ± 0.6[a]	6.5 ± 0.3[b]	7.2 ± 0.5[c]	9.7 ± 1.3[c]
	50 µg/kg/min†	4.4 ± 1.0[a]	6.2 ± 2.5[b]	7.4 ± 2.2[c]	7.6 ± 2.2[c]

*Treatments consisted of IV administration of a bolus of saline solution (0.05 mL/kg) followed by a saline solution CRI at a rate of 10 mL/h for 12 hours, IV administration of a bolus of lidocaine hydrochloride (1 mg/kg [0.05 mL/kg]) followed by a lidocaine CRI at a rate of 25 µg/kg/min for 12 hours, and IV administration of a bolus of lidocaine (1 mg/kg [0.05 mL/kg]) followed by a lidocaine CRI at a rate of 50 µg/kg/min for 12 hours. †Represents results for only 5 dogs.

[a–c]Within a row, values with different superscript letters differ significantly ($P < 0.05$).

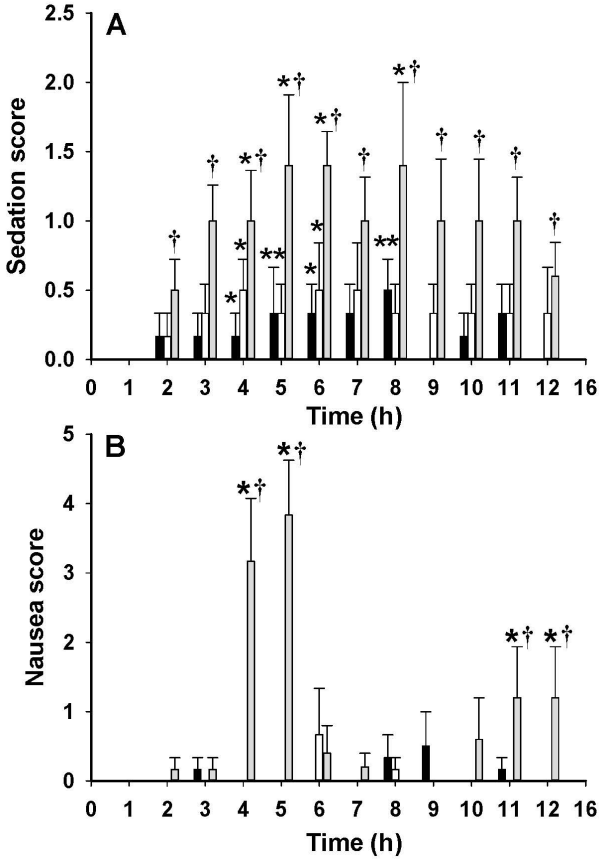

Figure 3—Sedation score (A) and nausea score (B) over time for clinically normal dogs fed a meal containing 30 BIPS that then received a bolus injection followed by a CRI of saline solution (black bars; n = 6), lidocaine at a rate of 25 µg/kg/min (white bars; 6), and lidocaine at a rate of 50 µg/kg/min (gray bars; 5) for 12 hours. Sedation score was on a scale of 0 to 4, and nausea score was on a scale of 0 to 5. ***See*** Figure 2 for remainder of key.

medicine.[32–38] Optimal dosing techniques in dogs include use of 1.5-mm spheres placed in a small amount of canned dog food or baby food and fed in a kibble ration. Use of larger-diameter BIPS (5.0 mm) is not recommended for assessment of gastrointestinal transit because of variability in gastric emptying of these spheres; they are more suitable for use in diagnosing other conditions such as obstruction.[33,34] However, when small BIPS are ingested, 75% are predicted to exit the stomach of clinically normal dogs by a mean ± SD of 10.8 ± 1.4 hours.[34] For the control treatment of the present study, gastric emptying of 75% of BIPS was detected at a mean ± SD of 7.0 ± 1.9 hours, which is slightly more rapid than has been previously reported. The reason for this difference is unclear. There may be variations among study populations of dogs, and body weight has been weakly associated with gastric emptying times[34]; however, these factors do not entirely explain the shorter gastric emptying times for the present study.

Lidocaine had no effects on gastric emptying times of the clinically normal dogs in the present study, which is consistent with results for a study[42] of horses in which short-term lidocaine CRIs minimally affected gastric emptying. In vitro experiments also have confirmed that lidocaine has no effect on the pyloric antrum of horses, although it increases contractile activity in the proximal portion of the duodenum when administered at 10 times the recommended clinical dose.[43] In addition, no differences in the presence of gastric reflux, presence of gastrointestinal sounds, and number of small intestinal contractions per minute were associated with lidocaine CRIs used before and after surgery in colic patients.[44] In fact, lidocaine may prolong fecal transit time in clinically normal horses.[45] However, in horses with postoperative ileus, lidocaine CRIs significantly reduce the amount of gastric reflux and decrease the duration of hospitalization.[26] Similarly, lidocaine CRIs in horses improve postoperative ileus, provide analgesia, and reduce the duration of hospitalization.[46,47]

Although there is a paucity of data concerning gastrointestinal tract effects and duration of hospitalization associated with lidocaine administration to dogs, data for the present study quantified transit time after administration of lidocaine CRIs and suggested that midtreatment (4 to 7 hours after start) is the period when more BIPs entered the colon or rectum when a lidocaine CRI at 50 µg/kg/min was administered. However, results for the present study should not be overemphasized because there were no significant differences in orocolic transit times among treatments.

Differences in outcomes among studies may be attributable to differences in species or health status of patients. The present study was performed with clinically normal dogs. Lidocaine CRIs may have more appreciable effects on intestinal transit in clinically affected patients because of direct analgesic effects[12,13] or effects on reduction of proinflammatory cytokines and toxic oxygen metabolites that can underlie ileus.[48,49] Lidocaine may also prevent inhibition of intestinal function by reducing sensory afferent transmission from affected bowel[46] or by precluding the effects of nonadrenergic, noncholinergic neurotransmitters affected by conditions associated with elevations in sympathetic tone (eg, enteritis, intestinal distension, and surgical manipulation[46,50–53]). Although a reduction in ileus may represent effects of multiple factors, it has not been determined whether any of the aforementioned mechanisms play a role in intestinal transit times of healthy dogs.

Dogs had higher nausea scores after receiving a lidocaine bolus (2 mg/kg, IV) and lidocaine CRIs in another study.[41] Although signs of nausea and vomiting were not quantified, use of higher doses (75 and 100 µg/kg/min; plasma concentration, approx 4 µg/mL) resulted in emesis between 4 and 8 hours after administration in 3 of 6 dogs.[41] In the study reported here, nausea score was only associated with the highest CRI of 50 µg/kg/min, especially at 4 and 5 hours and again at 11 and 12 hours after the start of treatment. Data for 1 dog were removed from the study because of excessive vomiting during administration of the 50-µg/kg/min treatment. However, vomiting resolved quickly following cessation of the lidocaine CRI, and no additional supportive care was required. We speculate that nausea score would be associated with initial high plasma concentrations of lidocaine following administration of a lidocaine bolus and further accumulation during a high-dose CRI. However, additional pharmacokinetic testing is needed because plasma concentrations of lidocaine were not measured in the present study.

Sedation is associated with lidocaine CRIs in dogs.[22,41] Investigators of 1 study[41] reported an increase in sedation at 30 minutes as well as 8 to 12 hours after administration of a lidocaine bolus and lidocaine CRI at 50 µg/kg/min. Results for the present study did not indicate an early phase of sedation, possibly because of the lower lidocaine bolus dose (1 mg/kg) for the present study, compared with the dose (2 mg/kg) for that other study.[41] However, data for the study reported here are consistent with results for that other study because sedation began 4 hours after CRI initiation and scores were significantly different from baseline values by 8 hours. Compared with other clinically used local anesthetics such as bupivacaine and ropivacaine, lidocaine has the least toxicity for the CNS and has the highest safety margin between the convulsant and lethal dose.[54] However, it is possible that sedation of dogs is associated with elevated plasma and CNS concentrations of lidocaine, similar to sedation effects in humans.[55]

The present study had limitations. Similar to results for other studies that involved the use of BIPS, it was difficult to determine the exact location of the markers in some cases because of superimposition of the intestines and stomach.[34] These inaccuracies could have led to underestimation of the gastric emptying time and gastrointestinal transit time. Gastric emptying time may have also been mildly underestimated because in a few cases, a small number of BIPS (1 or 2) had already passed into the duodenum in the short (approx 5-minute) delay between feeding of BIPS and when the first radiographs were obtained. Conversely, gastric emptying time and gastrointestinal tract transit time were overestimated because of the interval between radiographic imaging, which meant that times were rounded up to the next hour. In addition, gastrointestinal transit time inherently includes gastric emptying, so conclusions regarding small intestinal transit time separately from gastric emptying cannot be made. Obtaining radiographs more frequently may have made it possible to more accurately define emptying and transit times and to identify significant differences among treatments. However, it is unlikely that an increased frequency for BIPS quantification and identification of additional significant differences would be of clinical importance.

The present study included only clinically normal dogs. However, these results may be used for future comparisons of lidocaine's effects in dogs with abnormal gastrointestinal emptying. Results indicated that radiographic interpretation of small (1.5-mm in diameter) BIPS may be a viable choice for evaluation of gastrointestinal tract motility in dogs. In addition, only 6 dogs were included in the present study. Increasing the sample size may substantially increase the power of a study.

We chose to evaluate only 2 lidocaine CRI doses and did not generate a large dose-response curve. This was based on results of another study[41] in which there were adverse effects with higher doses (75 and 100 µg/kg/min) and on the fact these were CRI doses used clinically at our institution. However, gastrointestinal tract effects may have been accentuated (or possibly diminished) at higher doses.

Findings for the study reported here suggested that at clinical doses, lidocaine CRIs did not significantly affect gastric emptying. Administration of a

lidocaine CRI at a rate of 50 µg/kg/min resulted in a pattern whereby lidocaine reduced (but not significantly) gastrointestinal transit time and increased sedation and nausea scores. However, there were no significant differences in gastrointestinal transit time on the basis of the percentage of BIPS (25%, 50%, 75%, and 90%). To our knowledge, the study reported here was the first to include data on the impact that commonly used lidocaine CRIs may have on the gastrointestinal tract motility of conscious clinically normal dogs. However, effects must be evaluated in dogs that have painful conditions, are sick, or are arrhythmic and that are managed by use of daily lidocaine CRIs.

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Footnotes

a. Monoject veterinary IV catheter, Covidien Animal Health, Mansfield, Mass.
b. Provided by Medical ID Systems Inc, Grand Rapids, Mich.
c. Hospira Inc, Lake Forest, Ill.
d. Baxter Healthcare Corp, Deerfield, Ill.
e. SigmaPlot, version 12, Systat Software Inc, San Jose, Calif.

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Appendix

Sedation and nausea scoring, conducted in accordance with previously established scoring systems,[40,41] used for dogs receiving a bolus injection followed by a CRI of saline (0.9% NaCl) solution or lidocaine (25 and 50 μg/kg/min) for 12 hours.

Variable	Score	Description
Sedation[41]	0	Typical behavior
	1	Mild sedation, some decrease in activity, some resistance to handling, and response to name
	2	Moderate sedation, mild resistance to handling, spontaneous activity, and response to name (but response is slow)
	3	Moderate to heavy sedation, less spontaneous activity, verbal encouragement needed to induce standing, and minimal resistance to handling
	4	Sternal recumbency, physical stimulus required to induce standing, signs of depression, and no resistance to handling
Nausea[40]	0	No signs of discomfort*
	1	Seldom has signs of discomfort*
	2	Often has signs of discomfort*
	3	Signs of discomfort* are continuous; dog cannot be comforted and 1 vomiting episode
	4	2 vomiting episodes
	5	3 vomiting episodes

*Licking lips and nose, closing eyes, yawning, belching, grunting, vocalization, rapid breathing, movement, restlessness, and salivation.