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Effect of intraoperative constant rate infusion of lidocaine on short-term survival of dogs with septic peritonitis: 75 cases (2007–2011)

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OBJECTIVE
To investigate whether intraoperative administration of a lidocaine infusion to dogs with septic peritonitis was associated with short-term (48 hours) survival after surgery.

DESIGN
Retrospective case series.

ANIMALS
75 dogs with septic peritonitis.

PROCEDURES
Medical records of dogs with septic peritonitis that underwent laparotomy between January 2007 and December 2011 at the Royal Veterinary College were reviewed. Select variables during the preoperative, intraoperative, and postoperative periods and short-term survival after surgery were compared between dogs that received an opioid only (group O; n = 33) and dogs that received lidocaine (50 µg/kg/min [22.7 µg/kg/min], IV; group L; 42) in addition to an opioid during surgery.

RESULTS
The proportion of dogs that survived for 48 hours after surgery was significantly greater for group L (35/42) than for group O (20/33). Intraoperative infusion of lidocaine increased the odds of short-term survival (OR, 8.77; 95% CI, 1.94 to 39.57). No significant differences were observed between the 2 treatment groups for variables assessed during the preoperative and postoperative periods. During the intraoperative period, more dogs in group L received an IV bolus of a synthetic colloid than did dogs in group O, but the number of IV boluses administered was not associated with short-term survival.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that IV infusion of lidocaine might improve the short-term survival of dogs with septic peritonitis. Prospective clinical trials are necessary to determine the efficacy of lidocaine as a supportive treatment for dogs with septic peritonitis. (*J Am Vet Med Assoc* 2016;248:422–429)

Septic peritonitis is associated with a high mortality rate, and it is a major cause of sepsis in dogs. The most common predisposing cause for septic peritonitis is the contamination of (or translocation into) the peritoneal cavity by microorganisms normally present in abdominal organs.[1,2] Endotoxins produced by bacteria cause the release of inflammatory cytokines, including interleukin, tumor necrosis factor, and prostanoids, which contribute to vasomotor paralysis and capillary occlusion with secondary leakage of fluid into the interstitium.[3-7] The clinical signs of septic peritonitis may be vague, but distributive shock frequently develops and is characterized by tachycardia, hypotension, and a decrease in systemic vascular resistance subsequent to the inflammatory response.[3,5-10] Dogs with septic peritonitis may require anesthesia for diagnostic procedures or surgery, and they are generally poor anesthesia candidates because their hemodynamic stability is often compromised.

Lidocaine possesses analgesic and inflammatory modulator properties and is commonly used as a local anesthetic.[4-6,11] Intravenous infusion of lidocaine (33 to 50 µg/kg/min [15.0 to 22.7 µg/lb/min]) substantially diminishes the production of inflammatory cytokines in rats,[3] rabbits,[6] and horses[4] with experimentally induced endotoxemia and attenuates leukocyte adhesion to the endothelium of mice when it is infused before or immediately after IV administration of endotoxin.[5] In mice[5] and dogs[7] with experimentally induced sepsis, IV infusion of lidocaine decreases the

ABBREVIATIONS
ASA   American Society of Anesthesiologists
CI   Confidence interval
CRI   Constant rate infusion

mortality rate despite having no observable beneficial effects on systemic hemodynamics.

Few studies[7,8] have been conducted to investigate the effects of IV infusion of lidocaine in dogs with experimentally induced septicemia. The purpose of the study reported here was to investigate whether intraoperative administration of a lidocaine infusion to dogs with septic peritonitis was associated with survival within 48 hours after surgery.

Materials and Methods

Case selection

The medical record database for the Royal Veterinary College was searched between January 2007 and December 2011 to identify the records of dogs that contained the terms sepsis or peritonitis. Dogs were considered for study inclusion if they underwent a laparotomy and septic peritonitis was confirmed on the basis of identification of intracellular bacteria during cytologic evaluation or bacterial growth during bacteriologic culture of abdominal effusion fluid. Dogs were also considered for study inclusion if a perforation of the gastrointestinal or uterine wall was identified during an exploratory laparotomy. The anesthesia and intensive care records for those dogs were examined. The care of all dogs was managed by residents who were supervised by senior clinicians, and the use of an intraoperative lidocaine infusion was at the discretion of the attending anesthetist. Only dogs that received an opioid alone (group O) or an opioid plus lidocaine (2 mg/kg [0.9 mg/lb], IV bolus, followed by a CRI of 50 µg/kg/min; group L) during surgery were included in the study. Excluded from the study were dogs that underwent a laparotomy to diagnose or treat septic peritonitis within 48 hours prior to the surgery of interest, received lidocaine prior to surgery, received a loading dose or CRI of lidocaine different from that specified for study inclusion, or received multiple lidocaine IV boluses during the intraoperative and postoperative period.

Medical records review

For each dog included in the study, information extracted from the medical record included age, sex, weight, source of infection, clinical examination findings, source of peritonitis, ASA status, types and amounts of fluids and medications administered, and outcome at 48 hours after surgery.

Data analysis

Dogs were separated into 2 treatment groups on the basis of whether they received an opioid only (group O) or an opioid plus lidocaine (group L) during surgery. The data for each dog were separated into 3 time periods (preoperative, intraoperative, and postoperative) for analysis. Variables of interest for the preoperative period included heart rate, respiratory rate, body temperature, type of IV fluids administered before surgery, and time from hospital admission to induction of anesthesia (not evaluated for dogs that developed septic peritonitis as a result of complications from a previous surgery dur-

ing the same hospitalization). Variables of interest for the intraoperative period included ASA status immediately before anesthesia, types of anesthetic agents used, type of opioid administered, type and amounts of IV fluids administered, number of IV fluid boluses administered, number of dogs that received vasopressors and inotropes to support hemodynamic function, heart rate, duration of hypotension (systolic arterial pressure < 90 mm Hg or mean arterial pressure < 60 mm Hg for > 10 minutes), body temperature at extubation, and anesthesia duration. The postoperative period was defined as the 48 hours immediately after surgery. Variables of interest in the postoperative period included types of drugs used for analgesia, number of dogs that received a lidocaine infusion after surgery, type and amount of IV fluids administered, and number of dogs that received vasopressors and inotropes to support the cardiovascular system.

Within each period, variables of interest were compared between the 2 treatment groups. The data distributions for continuous variables were assessed for normality by use of the Kolmogorov-Smirnov test. For continuous variables that were normally distributed, comparisons between treatment groups were performed with independent Student t tests. For continuous variables that were not normally distributed, comparisons between treatment groups were performed with Mann-Whitney U tests. For categorical variables, the frequency distributions were reported as proportions and either a χ^2 test or Fisher exact test (for outcomes in which the number of dogs within at least 1 cell was ≤ 5) was performed to compare differences between the 2 treatment groups. The outcome at 48 hours after surgery (alive or dead) was compared between the 2 treatment groups by means of a χ^2 test. When the study population was stratified by ASA status immediately prior to anesthesia, the outcome at 48 hours after surgery was compared between the treatment groups within each stratum by use of a Fisher exact test. For all comparisons between treatment groups, values of $P < 0.05$ were considered significant.

Logistic regression analysis was used to evaluate the association between each of the variables of interest for all periods and the probability that a dog was alive 48 hours after surgery. Univariate models were evaluated initially, and variables with values of $P < 0.10$ on univariate analysis were eligible for inclusion in a multivariable model. A multivariable model was constructed by stepwise backward selection, and only variables with $P < 0.05$ were retained in the final model. A Hosmer-Lemeshow test was used to assess how well the final multivariable model fit the data. The OR and associated 95% CI for each variable retained in the final model were reported. All analyses were performed with a commercially available statistical software package.[a]

Results

Dogs

Seventy-five dogs met the inclusion criteria and were enrolled in the study. Group O (dogs that did

not receive lidocaine during surgery) consisted of 33 dogs and included 9 (27.3%) females and 24 males (72.7%; neuter status not reported for any dogs in the study) with a median age of 48 months (range, 3 to 142 months). Group L (dogs that received a CRI of lidocaine during surgery) consisted of 42 dogs and included 12 (28.6%) females and 30 (71.4%) males with a median age of 60 months (range, 5 to 126 months). The median age ($P = 0.304$) and sex distribution ($P = 1.000$) did not differ significantly between the 2 treatment groups. Body weight was categorized into 3 categories (< 10 kg [22 lb], 10 to 20 kg [22 to 44 lb], and > 20 kg). Of the 33 dogs in group O, 7 (21.2%) weighed < 10 kg, 6 (18.2%) weighed between 10 and 20 kg, and 20 (60.6%) weighed > 20 kg. Of the 42 dogs

in group L, 7 (16.7%) weighed < 10 kg, 11 (26.2%) weighed between 10 and 20 kg, and 24 (57.1%) weighed > 20 kg. The frequency distribution of dogs among the 3 weight categories did not differ significantly ($P = 0.526$) between the treatment groups. Within group O, the source of peritonitis was classified as gastrointestinal for 25 (75.8%) dogs, hepatobiliary for 2 (6.1%) dogs, urogenital for 1 (3.0%) dog, and other for 5 (15.2%) dogs. Within group L, the source of the peritonitis was classified as gastrointestinal for 33 (78.6%) dogs, hepatobiliary for 1 (2.4%) dog, urogenital for 3 (7.1%) dogs, and other for 5 (11.9%) dogs. The frequency distribution of dogs among the 4 categories for peritonitis source did not differ significantly ($P = 0.738$) between the treatment groups.

Table 1—Descriptive data for the outcomes of interest during the preoperative period for 75 dogs with septic peritonitis that did (group L; n = 42) and did not (group O; 33) receive an IV infusion of lidocaine (2 mg/kg [0.9 mg/lb], IV bolus, followed by a CRI of 50 μg/kg/min [22.7 μg/kg/min]) during laparotomy.

Outcome	Group O	Group L	P value
Heart rate (beats/min)	120 (50–200)	120 (60–188)	0.953
Respiratory rate (breaths/min)*	33 ± 14	34 ± 14	0.931
Body temperature (°C)†	38.5 (35.7–40.1)	38.1 (34.8–40.4)	0.250
Received IV infusion of lactated Ringer solution	—	—	0.338
Yes	20 (60.6)	30 (71.4)	—
No	13 (39.4)	12 (28.6)	—
No. of IV boluses (5 mL/kg) of lactated Ringer solution received	—	—	0.790
0	21 (63.6%)	23 (54.8%)	—
1	8 (24.2%)	15 (35.7%)	—
2	3 (9.1%)	3 (7.1%)	—
3	1 (3.0%)	1 (2.4%)	—
Received IV infusion of a synthetic colloid (6% hydroxyethyl starch in saline [0.9% NaCl] solution) solution	—	—	0.395
Yes	9 (27.3%)	7 (16.7%)	—
No	24 (72.7%)	35 (83.3%)	—
No. of IV boluses (1–2 mL/kg) of synthetic colloid fluids received	—	—	0.949
0	26 (78.8%)	31 (73.8%)	—
1	5 (15.2%)	6 (14.3%)	—
2	1 (3.0%)	3 (7.1%)	—
3	0 (0.0%)	1 (2.4%)	—
4	1 (3.0%)	1 (2.4%)	—
Received IV infusion of a blood product	—	—	1.000
Yes	1 (3.0%)	2 (4.8%)	—
No	32 (97.0%)	40 (95.2%)	—
Time from hospital admission to anesthesia‡	—	—	0.361
≤ 24 h	28 (87.5%)	31 (77.5%)	—
> 24 h	4 (12.5%)	9 (22.5%)	—

Values for the treatment groups represent the median (range), mean ± SD, or number (%) of dogs.
*Respiratory rate was recorded for only 29 dogs in group O and 37 dogs in group L. †Body temperature was recorded for only 31 dogs in group O and 40 dogs in group L. ‡The time from hospital admission to anesthesia was available for only 32 dogs in group O and 40 dogs in group L.
— = Not applicable.
To convert mL/kg to mL/lb, divide by 2.2.

Table 2—Descriptive data for the outcomes of interest during the intraoperative period for the dogs of Table 1.

Outcome	Group O	Group L	P value
ASA status	—	—	0.840
III	4 (12.1%)	4 (9.5%)	—
IV	17 (51.4%)	22 (57.1%)	—
V	12 (36.4%)	16 (33.3%)	—
Anesthesia induction agent used	—	—	0.952
Propofol	6 (18.2%)	7 (16.7%)	—
Alfaxalone	11 (33.3%)	13 (31.0%)	—
Fentanyl and midazolam	16 (48.5%)	22 (52.4%)	—
Anesthesia maintenance agent used	—	—	0.499
Isoflurane	33 (100%)	40 (95.2%)	—
Sevoflurane	0 (0%)	2 (4.8%)	—
Intraoperative opioid administered	—	—	0.327
Fentanyl	31 (93.9%)	37 (88.1%)	—
Methadone	2 (6.1%)	5 (11.9%)	—
IV infusion rate for lactated Ringer solution	—	—	0.689
≤ 10 mL/kg/h	31 (93.9%)	38 (90.5%)	—
> 10 mL/kg/h	2 (6.1%)	4 (9.5%)	—
No. of IV boluses (5 mL/kg) of lactated Ringer solution received	—	—	0.488
0	20 (60.6%)	22 (52.4%)	—
1	7 (21.2%)	11 (26.2%)	—
2	6 (18.2%)	6 (14.3%)	—
3	0 (0.0%)	3 (7.1%)	—
Received IV infusion of a synthetic colloid (6% hydroxyethyl starch in saline solution) solution	—	—	0.632
Yes	11 (33.3%)	17 (40.5%)	—
No	22 (66.7%)	25 (59.5%)	—
No. of IV boluses (1–2 mL/kg) of synthetic colloid fluids received	—	—	0.024
0	26 (78.8%)	20 (47.6%)	—
1	4 (12.1%)	9 (21.4%)	—
2	2 (6.1%)	8 (19.0%)	—
3	0 (0.0%)	4 (9.5%)	—
4	1 (3.0%)	0 (0.0%)	—
5	0 (0.0%)	1 (2.4%)	—
Received IV infusion of a blood product	—	—	0.507
Yes	7 (21.2%)	10 (23.8%)	—
No	26 (78.8%)	32 (76.2%)	—
Received a vasopressor	—	—	0.207
Yes	8 (24.2%)	15 (35.7%)	—
No	25 (75.8%)	27 (64.3%)	—
Received an inotrope	—	—	0.459
Yes	2 (6.1%)	7 (16.7%)	—
No	31 (93.9%)	35 (83.3%)	—
Heart rate (beats/min)*	120 (70–177)	115 (70–200)	0.843
Duration of hypotension†	—	—	0.673
≤ 10 min	10 (31.3%)	10 (23.8%)	—
10–25 min	7 (21.9%)	8 (19.0%)	—
> 25 min	15 (46.9%)	24 (57.1%)	—
Body temperature at extubation (°C)*	35.4 (34.1–38.4)	35.9 (33.1–38.2)	0.449
Anesthesia duration (min)*	185 (95–335)	210 (105–320)	0.202

Values for the treatment groups represent the median (range) or number (%) of dogs.

*Information available for only 31 dogs in group O and 41 dogs in group L. †Information available for only 32 dogs in group O and 42 dogs in group L.

— = Not applicable.

See Table 1 for remainder of key.

Preoperative period

Descriptive data for the outcomes of interest during the preoperative period were summarized **(Table 1)**. None of the outcomes assessed differed significantly between the treatment groups. The majority of the dogs (59/75 [79%]) were anesthetized for surgery within 24 hours after hospital admission, and only 13 (17%) dogs were anesthetized for surgery > 24 hours (range, 35 hours to 3 days) after hospital admission; the time from hospital admission to surgery was not reported for 3 (4%) dogs.

Intraoperative period

Descriptive data for the outcomes of interest during the intraoperative period were summarized **(Table 2)**. None of the outcomes assessed differed significantly between the treatment groups, except the number of IV boluses of synthetic colloid solution administered; more dogs in group L received at least 1 IV bolus of synthetic colloid during surgery than did dogs in group O ($P = 0.024$). The opioids most frequently administered to dogs during surgery were fentanyl (0.1 to 0.3 µg/kg/min [0.045 to 0.136 µg/lb/

Table 3—Descriptive data for the outcomes of interest during the postoperative period for the dogs of Table 1.

Outcome	Group O	Group L	P value
Received opioid for analgesia	—	—	1.000
Yes	31 (93.9%)	40 (95.2%)	—
No	2 (6.1%)	2 (4.8%)	—
Received lidocaine for analgesia	—	—	0.123
Yes	6 (18.2%)	15 (35.7%)	—
No	27 (81.8%)	27 (64.3%)	—
Received IV infusion of lactated Ringer solution	—	—	0.579
Yes	31 (93.9%)	41 (97.6%)	—
No	2 (6.1%)	1 (2.4%)	—
No. of IV boluses (5 mL/kg) of lactated Ringer solution received	—	—	0.201
0	28 (84.8%)	28 (66.7%)	—
1	3 (9.1%)	6 (14.3%)	—
2	0 (0.0%)	1 (2.4%)	—
3	0 (0.0%)	4 (9.5%)	—
4	1 (3.0%)	3 (7.1%)	—
≥ 5	1 (3.0%)	0 (0.0%)	—
Received IV infusion of a synthetic colloid (6% hydroxyethyl starch in saline solution) solution	—	—	0.816
Yes	14 (42.4%)	20 (47.6%)	—
No	19 (57.6%)	22 (52.4%)	—
No. of IV boluses (1–2 mL/kg) of synthetic colloid fluids received	—	—	0.949
0	28 (84.8%)	31 (73.8%)	—
1	3 (9.1%)	3 (7.1%)	—
2	2 (6.1%)	2 (4.8%)	—
3	0 (0.0%)	3 (7.1%)	—
4	0 (0.0%)	2 (4.8%)	—
≥ 5	0 (0.0%)	1 (2.4%)	—
Received IV infusion of a blood product	—	—	1.000
Yes	8 (24.2%)	10 (24.4%)	—
No	25 (75.8%)	31 (75.6%)	—
Received a vasopressor*	—	—	1.000
Yes	5 (15.2%)	7 (17.1%)	—
No	28 (84.8%)	34 (82.9%)	—
Received an inotrope*	—	—	0.725
Yes	3 (9.1%)	5 (12.2%)	—
No	30 (90.9%)	36 (87.8%)	—

Values for the treatment groups represent the median (range) or number (%) of dogs.
*Information available for only 41 dogs in group L.
— = Not applicable.
See Table 1 for remainder of key.

min], IV, CRI) and methadone (0.1 to 0.2 mg/kg [0.045 to 0.091 mg/kg], IV, intermittently as needed). The median duration of anesthesia for dogs in group L was longer than that for the dogs of group O; however, that difference was not significant ($P = 0.202$).

Postoperative period

Descriptive data for the outcomes of interest during the postoperative period were summarized **(Table 3)**. None of the variables assessed differed significantly between the treatment groups. The opioids most frequently administered during the postoperative period were morphine, methadone, and fentanyl. Some dogs also received lidocaine (30 µg/kg/min [13.64 µg/lb/min], CRI for 6 to 12 hours) for additional analgesia during the postoperative period.

Short-term survival after surgery

The proportion of dogs that remained alive at 48 hours after surgery was significantly ($P = 0.036$) greater for group L (35/42 [83.3%]) than that for group O (20/33 [60.6%]). Of the 13 dogs from group O that did not survive, 6 died of cardiac arrest and 7 were euthanized because of a deteriorating clinical condition. Of the 7 dogs from group L that did not survive, 3 died from cardiac arrest and 4 were euthanized because of a deteriorating clinical condition. When survival was assessed as a function of ASA status prior to surgery, all 12 dogs in group O that were classified as ASA V prior to surgery died within 48 hours after surgery, whereas only 5 of 16 (31.3%) dogs in group L that were classified as ASA V prior to surgery died within that same period ($P < 0.001$). The proportion of dogs in group O that were classified as ASA IV (1/17 [5.9%]) or ASA III (0/4) prior to surgery and died within 48 hours after surgery did not differ significantly ($P = 1.000$) from the proportion of dogs in group L that were classified as ASA IV (2/22 [9.1%]) or ASA III (0/4) prior to surgery and died within 48 hours after surgery.

Results of the multivariable logistic regression analysis revealed that a CRI of lidocaine significantly increased the odds of survival at 48 hours after surgery (OR, 8.77; 95% CI, 1.94 to 39.57; $P = 0.005$) when administered during the intraoperative period, but decreased the odds of survival at 48 hours after surgery (OR, 0.13; 95% CI, 0.03 to 0.52; $P = 0.004$) when administered during the postoperative period. Although the number of synthetic colloid IV boluses (1 to 2 mL/kg [0.45 to 0.9 mL/lb] of 6% hydroxyethyl starch in saline [0.9% NaCl] solution) administered appeared to decrease the odds of survival at 48 hours after surgery (OR, 0.71; 95% CI, 0.40 to 1.24), that association was not significant ($P = 0.227$).

Discussion

Results of the present study suggested that administration of lidocaine (2 mg/kg, IV bolus, followed by a CRI of 50 µg/kg/min) to dogs with septic peritonitis during surgery significantly increased the odds for short-term (ie, 48 hours) survival of those dogs after surgery. This finding supported the results of other studies that indicate intraoperative administration of lidocaine has analgesic, anti-inflammatory, and anti-endotoxin effects in horses,[4] mice,[5] rabbits,[6] and dogs.[11]

The survival rate for dogs with septic peritonitis ranges from 50% to 80%.[1,12] In individuals with sepsis, death is caused by dysfunction of multiple organ systems, and the likelihood of death increases as the number of dysfunctional organ systems increases.[2] In 1 study,[5] renal and hepatic functions were improved and the mortality rate was decreased for mice with experimentally induced septic peritonitis that received a CRI of lidocaine, compared with those of similar mice that did not receive a CRI of lidocaine. Endotoxins released during sepsis promote a hyperinflammatory state, which activates the coagulation cascade and causes adhesion of leukocytes to platelets and endothelium and results in disruption of the microcirculatory system and leakage of plasma macromolecules into the interstitium.[3,12,13] In human patients with sepsis, disruption or failure of the microcirculation in tissues is correlated with a poor outcome.[14] Administration of lidocaine immediately after endotoxin exposure inhibits the production of inflammatory cytokines in horses,[4] mice,[5] and rabbits.[6] Lidocaine suppresses in vitro platelet and leukocyte aggregation and P-selectin expression, which are sensitive indicators of life-threatening thrombotic diseases such as sepsis.[13] In rats infused with *Escherichia coli* endotoxin, administration of a CRI of lidocaine (33 µg/kg/min) decreases the leakage of fluorescein isothiocyanate–labeled bovine albumin into the peritoneal space.[3]

Results of other studies[7,8] suggest that administration of lidocaine to dogs with septicemia does not improve systemic vascular resistance or mean arterial pressure, although it does mitigate clinical signs of inflammation caused by infection. In the present study, the type and rate of IV fluids administered to stabilize hemodynamic variables were similar for the dogs of both treatment groups, even though the number of dogs in group L (dogs that received a CRI of lidocaine during surgery) that received an IV bolus of a synthetic colloid (1 to 2 mL/kg of 6% hydroxyethyl starch in saline solution) was significantly greater than that for group O (dogs that did not receive a CRI of lidocaine during surgery). However, the heart rate and incidence of hypotension (systolic arterial pressure < 90 mm Hg or mean arterial pressure < 60 mm Hg for > 10 minutes) did not differ significantly between the 2 treatment groups during the intraoperative period, and the number of synthetic colloid boluses administered was not significantly associated with the odds of short-term survival after surgery. In human patients with severe sepsis, small blood vessel perfusion is a better predictor for survival than is mean arterial pressure.[14] Consequently, systemic hemodynamic variables appear to be only marginally correlated with the survival probability of individuals with sepsis. The anti-inflammatory properties of lidocaine might reduce microcirculatory derangements, thereby improving tissue perfusion and de-

laying organ dysfunctions, despite less than optimal systemic hemodynamic variables.

Of the 54 dogs that were classified as hypotensive during the intraoperative period of the present study, only 32 (59%) received a vasopressor or inotrope. That finding could reflect decisions made by the anesthetists to manage mild to moderate decreases in systolic arterial blood pressure by reducing the amount of the volatile anesthetic administered or increasing the administration rate of IV fluids. Vasopressor or inotropes were likely administered only to hypotensive patients that failed to respond to changes in the flow rates of the volatile anesthetic and IV fluids administered. Also, the hemodynamic effects of vasopressors can be diminished in some patients with sepsis[9]; therefore, it is possible that some dogs remained hypotensive despite the use of vasopressors.

Volatile anesthetic agents exacerbate hemodynamic instability associated with sepsis by decreasing systemic vascular resistance in a dose-dependent manner and impairing tissue oxygen extraction.[10,15] The intraoperative use of opioids as part of a balanced anesthetic protocol reduces the requirement for volatile anesthetics.[11] However, opioids cause a dose-dependent, vagally mediated bradycardia that is counterbalanced by a baroreceptor-mediated increase in systemic blood pressure.[15] In patients with sepsis, that counterbalancing mechanism is inefficient, which can result in impairment of oxygen extraction.[15] For the dogs of group L, infusion of lidocaine in addition to administration of an opioid might have helped to decrease the end-tidal concentration of isoflurane required to maintain a surgical plane of anesthesia, which in turn might have had a positive effect on the function of the microcirculatory system.

The final multivariable logistic regression model indicated that infusion of lidocaine to dogs during the postoperative period had a negative effect on the probability of short-term survival. That finding might be a result of bias associated with the fairly small proportion of dogs (6/33 [18%] dogs in group O and 15/45 [33%] dogs in group L) that received lidocaine during the postoperative period and a type I error. Another plausible explanation for that finding was variation in the pharmacokinetics of lidocaine for animals with varying severity of endotoxemia. The mean plasma concentration of lidocaine was significantly higher in rats with experimentally induced sepsis than in healthy control rats for up to 2 hours after 1 injection of lidocaine (2 mg/kg).[16] Unfortunately, the information obtained for the present study did not allow us to draw any definitive conclusions regarding the mechanism behind the negative association between postoperative lidocaine infusion and short-term survival.

Limitations of the present study include a fairly small study population, the nonrandom nature of lidocaine administration, and the fact that data for all dogs were obtained retrospectively and may have suffered from bias associated with missing information, nonuniform record keeping, or operator-dependent clinical management. The study population could have

been increased by including dogs with septic peritonitis that did not undergo surgery; however, we feel that including those dogs in the study would have introduced confounding factors and increased bias because perioperative variables could not have been assessed in all dogs. Therefore, we purposely chose to focus only on dogs that underwent laparotomy to identify and possibly treat the source of the septic peritonitis.

Another limitation of the present study was the lack of a scoring system to classify the severity of the sepsis for each dog. To our knowledge, a scoring system to classify severity of sepsis has not been validated for use in veterinary patients, and the method used to diagnose systematic inflammatory response syndrome (ie, > 2 of 4 criteria present) is most frequently used to evaluate the severity of illness for dogs with septic peritonitis.[17] Unfortunately, the records for only a few dogs of the present study contained sufficient information for application of that method. Therefore, we decided to use ASA status prior to surgery as a surrogate measure of disease severity.

The total amount of lidocaine administered during surgery was not standardized for all dogs in group L and was dependent on the duration of surgery, which ranged from 1 to 3 hours. Thus, amount of lidocaine administered during surgery might have been a confounding factor in this study. To our knowledge, studies to evaluate the effect of different infusion rates of lidocaine are lacking; however, in a study[5] that involved mice with experimentally induced septic peritonitis, no significant differences were observed between mice that received lidocaine at a CRI of 42 µg/kg/min (19.1 µg/lb/min) and those that received lidocaine at a CRI of 83 µg/kg/min (37.7 µg/lb/min).

Results of the present study indicated that a CRI of lidocaine (50 µg/kg/min) can be administered in conjunction with an opioid as part of a balanced anesthesia regimen to improve intraoperative analgesia for dogs that underwent surgery for septic peritonitis. Intraoperative infusion of lidocaine might improve the short-term survival of dogs with septic peritonitis; however, prospective standardized clinical trials are necessary to determine the efficacy of lidocaine as a supportive treatment for dogs with septic peritonitis.

Footnotes

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From this month's *AJVR*

Muscle activity and hand motion in veterinarians performing laparoscopic training tasks with a box trainer

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February 2016

OBJECTIVE
To evaluate muscle activity and hand motion in veterinarians performing a standard set of laparoscopic training tasks.

SAMPLE
12 veterinarians with experience performing laparoscopic procedures.

PROCEDURES
Participants were asked to perform peg transfer, coordination, precision cutting, and suturing tasks in a laparoscopic box trainer. Activity of the right biceps brachii, triceps brachii, forearm flexor, forearm extensor, and trapezius muscles was analyzed by means of surface electromyography. Right hand movements and wrist angle data were registered through the use of a data glove, and risk levels for the wrist joint were determined by use of a modified rapid upper limb assessment (RULA) method. One-way repeated-measures ANOVA with a Bonferroni post hoc test was performed to compare values between tasks.

RESULTS
Activity in the biceps muscle did not differ significantly among the 4 tasks. Activity in the triceps, forearm flexor, and forearm extensor muscles was significantly higher during precision cutting than during the coordination task. Activity in the trapezius muscle was highest during the suturing task and did not differ significantly among the other 3 tasks. The RULA score was unacceptable (score, 3) for the coordination, peg transfer, and precision cutting tasks but was acceptable (score, 2) for the suturing task.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that the ergonomics of laparoscopic training depended on the tasks performed and the design of the instruments used. Precision cutting and suturing tasks were associated with the highest muscle activity. Acceptable wrist position, as determined with the RULA method, was found with the suturing task, which was performed with an axial-handled instrument. (*Am J Vet Res* 2016;77:186–193)
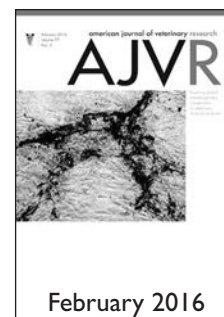
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