Article

Evaluating the effect of intraoperative peritoneal lavage on bacterial culture in dogs with suspected septic peritonitis

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Abstract — This pilot study describes the effect of intraoperative peritoneal lavage (IOPL) on bacterial counts and outcome in clinical cases of septic peritonitis. Intraoperative samples were cultured before and after IOPL. Thirty-three dogs with presumed septic peritonitis on the basis of cytology were managed surgically during the study period. Positive pre-lavage bacterial cultures were found in 14 cases, 13 of which were a result of intestinal leakage. The post-lavage cultures showed fewer isolates in 9 cases and in 1 case became negative. The number of dogs with a decrease in the concentration of bacteria cultured from pre-lavage to post-lavage samples was not statistically significant. There was no significant effect of the change in pre- to post-lavage culture, single versus multiple types of bacteria, selection of an appropriate empiric antimicrobial on survival or the need for subsequent surgery.

Résumé — Évaluation de l'effet d'un lavage péritonéal intra-opératoire sur la culture bactérienne chez des chiens atteints d'une péritonite septique suspectée. Cette étude pilote décrit l'effet d'un lavage péritonéal intra-opératoire sur les numérations bactériennes et les résultats dans des cas cliniques de péritonite septique. Des échantillons intra-opératoires ont été cultivés avant et après un lavage péritonéal intra-opératoire. Trente-trois chiens atteints d'une péritonite septique présumée basée sur la cytologie ont été gérés par chirurgie durant la période de l'étude. Des cultures bactériennes positives avant le lavage ont été trouvées dans 14 cas, dont 13 étaient le résultat d'une fuite intestinale. Les cultures après le lavage ont montré moins d'isolats dans 9 cas et dans 1 cas étaient négatives. Le nombre de chiens présentant une baisse de la concentration des bactéries cultivées d'échantillons avant le lavage et après le lavage n'était pas statistiquement significatif. Il n'y a eu aucun effet significatif du changement dans la culture avant et après le lavage, d'un type unique par rapport à des types multiples d'espèces bactérinnes, du choix empirique d'un antimicrobien approprié sur la survie ou le besoin d'une chirurgie subséquente.

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Introduction

Septic peritonitis is a potentially life-threatening infectious process that results from bacterial contamination of the peritoneal cavity. The most common source of abdominal contamination causing septic peritonitis is the gastrointestinal tract, often as a result of intestinal perforation due to foreign bodies, administration of non-steroidal anti-inflammtory drugs (NSAIDs), neoplasia, or dehiscence of previous surgical sites. Other sources of contamination leading to septic peritonitis include the biliary tract, the urogenital tract, less commonly external perforating trauma or pancreatitis, and in rare cases, the cause may be idiopathic (1–15).

Surgical management of septic peritonitis centers on identifying and correcting the source of contamination followed by removal of debris and contaminants using intraoperative peritoneal lavage (IOPL) and postoperative drainage (1–13). Survival rates in dogs and cats with septic peritonitis range from 30% to 80% (1–14). Septic peritonitis in animals is often suspected based on physical examination, clinical signs, history of previous intestinal surgery, diagnostic imaging findings consistent with abdominal effusion or the presence of pneumoperitoneum, cytological evidence of suppurative inflammation with or without the presence of bacteria, and/or positive culture. Confirming a diagnosis of septic peritonitis is typically based on 1 of the following criteria: cytological evidence of bacteria in the abdominal effusion sample, surgical or postmortem findings that confirm the rupture of a contaminated viscus (typically intestine) with or without evidence of serosal inflammation, or a positive bacterial culture (1,2,13). In 1 study only 14/28 dogs confirmed to have

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septic peritonitis had a positive bacterial culture and there was no difference in the number of positive bacterial cultures among survivors and non-survivors (2).

Although IOPL is stated to be important when treating septic peritonitis (1,6,16,17), no veterinary study has evaluated the efficacy of lavage on clearance of bacteria from the peritoneal cavity in clinical septic peritonitis and its effect on survival. Intraoperative peritoneal lavage for septic peritonitis is thought to remove gross contamination and to dilute the contaminants, but lavage also removes inflammatory mediators and other components of the normal peritoneal defense mechanisms including immune cells (18,19). Lavage may spread localized peritonitis; however, the normal intraperitoneal circulation rapidly disseminates contaminants regardless of lavage and lavage reduces the level of contamination that could otherwise be spread throughout the abdominal cavity (20–22).

Intraoperative peritoneal lavage is controversial in human abdominal surgery (17,23). In humans less than 10 L of saline solution decreased bacterial counts in diluted peritoneal fluid but did not reduce postoperative infectious complications (18). Another study determined that more than 21 L of sterile saline should be used to treat human patients with septic peritonitis (24). A significant decrease in the number of infectious complications was noted with a larger lavage volume (63% for $<$ 8.5 L *versus* 11% for 21 L) (24). Another study reported that a mean of 25 L significantly reduced infectious complications (25). Although a large volume of lavage fluid is indicated, a specific dose in mL/kg body weight (BW) has not been determined. An appropriate volume of lavage has also not been determined in veterinary medicine, but 1 author (26) recommends the use of 200 to 300 mL/kg BW of sterile saline for peritoneal lavage in the surgical management of septic peritonitis, although a reference is not provided for this recommendation.

The objective of this pilot study was to evaluate the impact of IOPL on peritoneal fluid bacterial culture results in canine patients with suspected septic peritonitis. The hypothesis was that IOPL would decrease the amount of bacteria cultured from abdominal fluid.

Materials and methods

Dogs in the study were admitted to the Ontario Veterinary College Health Sciences Centre (OVCHSC) between November 2003 and July 2007 and had pre-lavage and post-lavage abdominal cultures for suspected septic peritonitis. The suspicion of septic peritonitis in these cases was made on the basis of 1 or more of the following: sonographic evidence of free abdominal fluid in the presence of a foreign body or mass, or following previous intestinal surgery for foreign body removal or biopsy; abdominal fluid cytology reported by the pathologist as consistent with septic peritonitis (suppurative inflammation) with or without evidence of intracellular bacteria; surgical findings consistent with septic peritonitis such as contamination from a ruptured viscus; or a positive bacterial culture of the abdominal fluid. Septic peritonitis was considered confirmed only in cases in which a positive pre-lavage surgical fluid culture was obtained. Clinicians were asked to note the patient's case number, to collect pre- and post-lavage culture samples (aerobic and anaerobic) intraoperatively, and to record the amount of lavage fluid used. Samples of abdominal effusion were collected for aerobic and anaerobic bacterial culture at surgery, immediately upon entering the abdominal cavity (pre-lavage culture), and following surgical management of the underlying cause of peritonitis and peritoneal lavage but prior to closure of the abdomen (post-lavage culture). Samples for aerobic culture were collected using a commercial swab (Aerobic BBL culture swab; Becton, Dickinson and company, Sparks, Maryland, USA) and were refrigerated until plating could be performed. Samples for anaerobic culture were taken using sterile swabs (Anaerobic Tort-a-CUL; Becton, Dickinson and company) that were immediately placed in a sealed, oxygen-free, pre-reduced gel left at room temperature in the laboratory until plating could be performed. Aerobic samples obtained Monday to Saturday during laboratory business hours were plated upon submission. Anaerobic samples were plated at the end of the business day. Samples collected late on Saturday, on Sunday, and in the evening were plated the next business day. Non-selective aerobic and anaerobic culture, and susceptibility testing were performed using standard methods, and growth was assessed using a semi-quantitative scoring method (no growth, 1+, 2+, 3+, 4+). Age, sex, breed, body weight, medical, and/or surgical management performed prior to referral, and results of abdominal fluid cytology were recorded. The source of contamination identified at surgery, duration of surgical procedure, pre- and post-lavage culture results, antimicrobial susceptibility profiles, antimicrobials administered empirically (preoperatively), post-culture antimicrobials and postoperative outcome (survival and additional surgery) were also recorded. An appropriate antimicrobial was defined as one to which the bacteria were susceptible based on culture and susceptibility obtained at the time of surgery at the OVCHSC.

Statistical analyses were performed using SAS 9.2 (SAS Institute, Cary, North Carolina, USA). Descriptive statistics for age and weight are provided. Categorical data were evaluated using a two-tailed Fisher's exact test. A binomial test was used to evaluate the number of cases that had a decrease in the concentration of bacteria cultured pre-lavage to the amount cultured post-lavage. A P-value of < 0.05 was considered significant. Under the null hypothesis that there is a 50/50 chance to change or stay the same, a binomial power calculation was performed. A one-tailed test with an alpha error rate of 0.05 and a power of 0.95 was used to find a 75% rate of change in the number of bacteria cultured between pre- and post-lavage among culture-positive dogs. The one-sided alternative hypothesis, therefore, is that at least 75% of culture-positive dogs will increase their scores.

Results

Thirty-four dogs were enrolled in this study on the basis of suspected septic peritonitis. One dog died intraoperatively and was excluded from further data analysis. There were 6 mixed breed dogs, 4 Golden retrievers, 3 Labrador retrievers, and 1 of each of the following: west highland white terrier, miniature schnauzer, Siberian husky, American cocker spaniel, Doberman pinscher, Cesky terrier, Wheaten terrier, Nova Scotia duck tolling retriever, Yorkshire terrier, German shepherd, Bernese mountain

Table 1. Summary of cases of suspected septic peritonitis: etiology, cytology, empiric antimicrobial, bacterial culture results, and outcome

Case number	Etiology	Appropriate empirical antimicrobial	Pre-lavage culture	Post-lavage culture	Outcome
1	Biliary	NA	Negative	Negative	Euthanized
2	Previous Int surgery at rDVM	NA	Negative	Negative	Alive
3	Int neoplasia (ileocecal)	No	Positive	Positive	Euthanized
4	Previous Int surgery at rDVM	No	Positive	Positive	Euthanized
5	Int neoplasia (duodenal)	NA	Negative	Positive	Euthanized
6	Int ulceration	Yes	Positive	Positive	Euthanized
7	Biliary	NA	Negative	Negative	Euthanized
8	Previous Int surgery at rDVM	No	Positive	Positive	Alive
9	Pyometra	NA	Negative	Negative	Alive
10	Biliary	NA	Negative	Negative	Alive
11	Previous Int surgery at rDVM	NA	Negative[a]	Negative[a]	Alive
12	Int neoplasia (jejunal)	NA	Negative	Negative	Alive
13	Previous Int surgery at rDVM	Yes	Positive	Positive	Alive
14	Previous Int surgery at rDVM	No	Positive	Positive	Alive
15	Previous Int surgery at rDVM	No	Positive	Positive	Alive
16	Int ulceration	Yes	Positive	Positive	Alive
17	Int ulceration	No	Positive	Positive	Alive
18	Biliary	NA	Negative	Positive	Alive
19	Biliary	NA	Negative	Negative	Euthanized
20	Biliary	NA	Negative	Negative	Alive
21	Biliary	NA	Negative	Negative	Euthanized
22	Pancreatitis	NA	Negative	Negative	Alive
23	Previous Int surgery at the OVCHSC	No	Positive	Positive	Alive
24	Pancreatitis	NA	Negative	Negative	Alive
25	Pyometra	No	Positive	Negative	Alive
26	Previous Int surgery at rDVM	Yes	Positive	Positive	Alive
27	Previous Int surgery at rDVM	No	Positive	Positive	Alive
28	Ruptured mesenteric root abscess	NA	Negative	Negative	Alive
29	Previous Int surgery at rDVM	NA	Negative	Negative	Alive
30	Int ulceration	NA	Negative	Negative	Euthanized
31	Biliary	NA	Negative	Negative	Alive
32	Int ulceration	NA	Negative	Negative	Euthanized
33	Int ulceration	Yes	Positive	Positive	Euthanized

[a] Positive for *Candida albicans*.
rDVM — referring veterinarian, OVCHSC — Ontario Veterinary College Health Sciences Centre, Int — intestinal, NA — not applicable/not performed.

dog, border collie, Shetland sheepdog, dachshund, boxer, Alaskan malamute, Airedale terrier, bichon frisé, Finnish spitz, and Australian shepherd. There were 4 intact males, 14 castrated males, 2 intact females, and 13 spayed females. Median age at the time of presentation was 6.58 y (range: 0.67 to 13.8 y). Median body weight was 25.4 kg (range: 3.1 to 44 kg).

Based on surgical findings, the source of suspected septic peritonitis was classified as: biliary rupture (n = 8), intestinal foreign body surgery (n = 10) or intestinal biopsies (n = 1) performed prior to presentation at the OVCHSC, intestinal foreign body surgery performed at the OVCHSC (n = 1), perforated duodenal ulcer (n = 6), ruptured intestinal neoplasia (n = 3), ruptured pyometra (n = 2), peritonitis secondary to pancreatitis (n = 2), and a ruptured mesenteric root abscess (n = 1) (Table 1).

Fourteen of 33 cases (42%) had a positive pre-lavage culture (Table 1). Nine of these 14 dogs had a decrease in the concentration of bacteria grown from the post-lavage samples compared with the pre-lavage samples. One of 14 cases with a positive pre-lavage sample had no growth in the post-lavage sample. There was no significant difference between the 9 cases with a documented decrease in bacterial counts following lavage and the 5 cases with no change in bacterial concentration (P = 0.424). Positive pre-lavage bacterial cultures were obtained in 8/10 cases that had undergone surgery to remove an intestinal foreign body prior to admission at the OVCHSC. Positive pre-lavage bacterial cultures were also obtained in 4/6 cases with duodenal perforation secondary to NSAID or steroid administration, in 1/3 cases with a perforated intestinal tumor, and in 1/2 cases with ruptured pyometra. All dogs with pancreatitis, bile peritonitis, and mesenteric abscess had negative pre-lavage bacterial cultures. A significantly greater number of cases with an intestinal source of contamination had a positive pre-lavage culture compared with other sources of contamination (P = 0.0021).

The source of contamination, pre- and post-lavage culture results, and associated outcome are summarized in Table 2. One dog had a positive culture for *Candida albicans* on the pre- and post-lavage samples and was treated as a non-septic abdomen for the purposes of data analysis. Two additional cases with surgical findings consistent with septic peritonitis had negative pre-lavage cultures but had positive post-lavage bacterial cultures; the first dog had a traumatic rupture of the common bile duct and the second had a ruptured duodenal tumor. Including these 2 cases, 15 dogs had positive post-lavage samples. No new isolates were identified in post-lavage cultures in cases with a positive pre-lavage culture. The concentration of bacteria in the pre- and post-lavage cultures, the bacterial isolates, changes in culture results, and antimicrobial susceptibility, as well as the source of contamination and volume of lavage used are summarized in Table 2.

Table 2. Summary of cases with positive bacterial cultures including source, bacterial isolates, and outcome

Case number	Source	Pre-lavage culture result/ susceptibility	Post-lavage culture result/ susceptibility	Volume of lavage (mL/kg BW)	Outcome
3	I	*E. coli* 3+/no resistance, *Bacteroides fragilis* 1+ no resistance	*E. coli* 2+/no resistance *Bacteroides fragilis* 1+/no resistance	412	Euthanized
4	I	*E. coli* 2+/no resistance *Bacteroides fragilis* 3+/no resistance	*Bacteroides fragilis* 3+/no resistance	526	Euthanized
5	IN	Negative	*Clostridium perfringens* 1+/no profile provided	95.5	Euthanized
6	I	*E. coli* 1+/amox/clav, enro, gent, tetra, TMS	Same as pre-lavage	Copious	Euthanized
10	I	*E. coli* 1+/only gent *Streptococcus* sp. α-hemolytic/only cefoxitin	*E. coli* 1+/only gent	400	Alive
13	I	*Enterococcus* sp. 3+/amox/clav, ampi, tetra *Bacteroides fragilis* 4+/no profile available	*Enterococcus* sp. 1+/same as pre-lavage *Bacteroides fragilis* 1+	Copious	Alive
14	I	*Enterococcus* sp. 1+/only tetra	*Enterococcus* sp. 1+/only tetra	Copious	Alive
15	I	*Citrobacter freundii* 4+/enro, gent, tetra, TMS *Staphylococcus intermedius* 1+/amox/clav, cephalo, clinda, enro, gent, tetra, TMS	Same as pre-lavage	Until clear	Alive-required second surgery
16	I	*Enterococcus* sp 1+/ampi, enro, kanamycin	Same as pre-lavage	212	Alive
17	I	Bacillus spp. 2+/no profile provided	Same as pre-lavage	Copious	Alive
18	B	Negative	*Streptococcus* sp. 1+/no resistance	Copious	Alive
23	I	*Enterococcus* sp. 4+/gent, tetra *Staph. intermedius* 2+/all Strep sp. 4+/amox/clav, ampi, TMS	*Enterococcus* sp. 2+/same profile *Streptococcus* sp. 2+/same profile	Copious	Alive
25	UG	*E. coli* 1+/amox/clav, ampi, enro, gent, tetra, TMS	Negative	539	Alive
26	I	*E. coli* 3+/enro, gent, TMS *Klebsiella oxytoca* 1+/amox/clav, enro, gent, tetra, TMS	*E. coli* 1+/same profile	Copious	Alive
27	I	*Klebsiella pneumoniae* 2+/amox/clav, enro, cephalo, gent	*Klebsiella pneumoniae* 1+/same profile	Copious	Alive
33	I	*Klebsiella pneumoniae* 3+/amox/clav, cephalo, enro, gent, tetra, TMS	*Klebsiella pneumoniae* 1+/same profile	Copious	Euthanized

Source: I — previous intestinal surgery, IN — intestinal neoplasia, UG — urogenital, B — biliary. Antimicrobials: amox/clav — amoxicillin/clavulanate, gent — gentamicin, enro — enrofloxacin, tetra — tetracycline, ampi — ampicillin, cephalo — cephalothin, TMS — trimethoprim/sulfadiazine.

Overall, 11/33 dogs died or were euthanized. There was no difference in survival rate for dogs with positive pre-lavage bacterial culture (71%) *versus* those with a negative pre-lavage bacterial culture (63%) ($P = 0.72$). The survival rate for dogs with positive pre- and post-lavage cultures was 9/13 (69%). There was no significant difference between survival rates for the various sources of contamination ($P = 0.71$). There was no significant difference in survival between dogs that had a decrease in the concentration of bacteria and dogs that had no change in the concentration of bacteria cultured ($P = 1.0$). There was no association between survival and whether 1 *versus* multiple bacterial isolates were identified ($P = 1.0$).

All dogs had received antimicrobials prescribed by the referring veterinarian prior to admission and 25/33 dogs (76%) received additional antimicrobials following admission to the OVCHSC prior to intraoperative sampling for bacterial culture. The antimicrobials used at the OVCHSC included clindamycin, enrofloxacin, cefoxitin, ampicillin, cefazolin, metronidazole, and combinations of these. All dosages recorded in the medical records were verified and found to be appropriate based on published antimicrobial doses in veterinary medicine; however, the duration of administration prior to presentation was not consistently recorded in letters from referring veterinarians. The antimicrobial(s) selected empirically prior to surgery (administered by referring veterinarian or at the OVCHSC) was effective against the bacterial isolates *in vitro* in only 5/14 cases with a positive pre-lavage culture. Of these 5 dogs, 3 had a change in pre-lavage to post-lavage culture and none had a negative post-lavage culture. Six of the 9 dogs that received inappropriate empirical antimicrobial survived and 3 were euthanized due to poor progression of their clinical condition post-operatively. There was no association between the selection of an appropriate empirical antimicrobial and survival ($P = 0.58$).

The amount of sterile saline lavage used intraoperatively in those cases with positive pre- and/or post-lavage bacterial cultures was recorded in the surgical report of 6 patients (Table 2). The mean volume of lavage used in the 5 dogs with a positive pre-lavage culture was 417.8 mL/kg BW. The mean volume of lavage recorded for 4 cases that had a reduction in the number and/or type of bacteria cultured in the pre- to post-lavage culture

result was 469 mL/kg BW. The volume of lavage recorded for 1 of the 2 cases in which a negative pre-lavage with a positive post-lavage culture was encountered was 95.5 mL/kg BW (Table 2). A closed suction drain was placed in 31/33 abdomens; all 16 dogs with positive pre- and/or post-lavage cultures had an abdominal drain placed.

Nine dogs (4 with positive and 5 with negative pre-lavage cultures) underwent additional surgery at the OVCHSC following the surgery in which the cultures were obtained. There was no association between a positive pre-lavage culture result and the need for subsequent surgery ($P = 1.0$). Surgical findings included negative exploratory laparotomy (1 dog), dehiscence of an intestinal resection and anastomosis site (4 dogs), dehiscence of a duodenotomy site post biliary surgery (1 dog), fulminant pancreatitis with secondary extrahepatic biliary obstruction (1 dog), perforating pyloric ulcer (1 dog), and common bile duct rupture (1 dog). There was no association between the source of initial abdominal contamination and the need for subsequent surgery ($P = 1.0$). Of these cases, 4 had positive intraoperative cultures at the time of repeat surgery. *Enterococcus* sp. was isolated in 3 dogs and *Enterobacter cloacae* in 1 dog. In 2 of the cases with positive cultures at the time of repeat surgery the new isolates were different from those obtained at the time of first surgery. In both cases, the empirical antimicrobial administered during and after the first surgery was appropriate for the bacteria cultured at the time of first surgery but was ineffective *in vitro* against the bacterium recovered at the second surgery. There was no association between the choice of an antimicrobial to which the bacteria were susceptible *in vitro* and the need for additional surgery ($P = 0.58$). In 2 cases, the pre- and post-lavage cultures were negative but intraoperative cultures at the second surgery were positive. Of the 9 dogs that required subsequent surgery, 5 dogs were euthanized and 4 were discharged. Of the 4 cases with positive bacterial cultures, 3 dogs were euthanized and 1 dog was discharged.

Discussion

The goal of this study was to evaluate the effect of lavage on intraoperative bacterial cultures in clinical cases of septic peritonitis. Nine of 14 cases with a positive bacterial culture on the pre-lavage sample had a reduced concentration of bacteria cultured from the post-lavage sample. In the absence of control cases, it is impossible to attribute these reductions to the lavage. However, once the underlying etiology was managed surgically, lavage was the only treatment performed intraoperatively that was expected to decrease bacterial counts in these cases. Systemic antimicrobial administration instituted hours to days prior to obtaining the culture samples may have prevented some bacteria from being isolated from pre-lavage samples but was unlikely to have affected the culture samples obtained post-lavage. The goal of IOPL was to decrease the concentration of bacteria and it is not surprising that only 1 case with a positive pre-lavage culture had a negative post-lavage culture. Samples from 2 dogs with negative pre-lavage culture had bacterial growth from the post-lavage sample, possibly due to mobilization of bacteria from a localized septic focus or to iatrogenic contamination in the case that required a duodenotomy for biliary tract surgery. Other strategies used in the surgical management of septic peritonitis to eliminate or reduce abdominal contamination involve removing the source of contamination, providing a conduit for continued removal postoperatively with a closed suction drain, and administering systemic antimicrobials based on bacterial culture results.

In the present study, cases were analyzed as confirmed cases of septic peritonitis only when a positive pre-lavage culture was obtained. The number of cases available for analysis was therefore limited. A power calculation showed that a minimum of 49 cases with a positive culture (confirmed septic peritonitis) is required, but since the estimated proportion of confirmed septic peritonitis is 42.4% (14/33), 161 dogs would be needed to obtain the 49 culture-positive dogs.

A likely reason for some of the negative bacterial culture results in this study was the source of peritonitis. As was seen in this study, pancreatitis and bile peritonitis are often reported to result in a sterile chemical peritonitis (12,14). These cases were included as suspected septic peritonitis due to their clinical presentation and the results of cytology which suggested a suppurative effusion where sepsis could not be ruled out. Another likely reason for some of the negative culture results is that all dogs in the study had received antimicrobials prior to sampling. The administration of an appropriate dose of an antimicrobial to which the organism was susceptible prior to obtaining bacterial culture samples could have decreased the yield of positive bacterial cultures from peritoneal fluid. Because some antimicrobials were administered at the referring clinic while others were administered at the OVCHSC it was impossible to determine the duration of treatment or the cumulative dose of antimicrobials administered prior to sampling. The concentration of antimicrobials in the abdominal effusion may have been affected by the degree of serosal inflammation, the volume of peritoneal fluid, presence of necrotic tissue or fibrin clots, and the clinical status of the patient which could affect drug distribution depending on tissue perfusion and duration of treatment.

The time between collection and culture of the peritoneal fluid samples and the duration of storage varied depending on the day and time of surgery. Sample handling (prolonged refrigeration for aerobic samples obtained in evenings and on weekends) may have affected our results and potentially decreased the number of positive pre-lavage cases. This is an important consideration in the clinical management of these cases and cytology and Gram stain should be considered in all cases of septic peritonitis in the event that culture provides a false negative result. The rate of positive results may be altered in an institution where laboratory facilities are available for extended hours or if different sampling or culture methods are used.

Previous retrospective studies report that *E. coli* and other Gram-negative bacteria (*Bacteroides* spp., *Pasteurella mirabilis, Acinetobacter baumanii,* and *Klebsiella* spp.) were most commonly isolated in dogs with septic peritonitis (1,2). The bacteria isolated most commonly in the current study were: *E. coli,* followed by *Enterococcus* sp. then *Klebsiella* sp. and *Bacteroides.* Intestinal leakage is more likely to result in bacterial contamination due to the presence of large numbers of bacteria in the

intestines, particularly in the more aboral segments of the intestinal tract. Common bacterial isolates in human septic peritonitis include *E. coli, Enterococcus* sp., *Klebsiella* spp., *Streptococcus* spp., *Staphylococcus* spp., and *Bacteroides* species (27,28). *Enterococcus* sp. and *Bacteroides* spp. can lower the lethal dose of *E. coli* and Jett et al (30) found a significantly higher failure rate in humans with a positive culture for *Enterococcus* (29,30). Growth of *Enterococcus* spp. was confirmed in 4 cases of the present study and, although all 4 dogs survived, the number of cases is too small to make any statistical conclusions.

In the late 1960's, the effect of IOPL on bacterial culture was experimentally evaluated in dogs and was shown to reduce the number of positive cultures from 5/6 dogs to 2/6 dogs but conferred no survival advantage compared to other treatment (31). This is consistent with the results of our study but may also have been related to a lack of statistical power. In a canine experimental study in which septic peritonitis was induced by creating an avascular loop of ileum, 35% of 26 dogs treated with peritoneal lavage survived while none of 15 dogs treated with parenteral fluids alone survived (32). A study performed in rats with experimentally induced peritonitis suggested that peritoneal lavage (via a percutaneous catheter) resulted in a 70% decrease in mortality compared with antibiotics and subcutaneous fluid administration (33). A human clinical study in which IOPL was performed with 5 L of saline led to a reduction in bacterial counts but did not appear to influence postoperative survival (23). The authors of this study hypothesized that the low volume of lavage lead to dissemination of the organisms rather than removal.

The overall survival rate in the present study was similar to previously reported survival rates for septic peritonitis in dogs (1–14). The survival rate for dogs with a positive culture was not significantly different than the survival rate in dogs with a negative bacterial culture. In addition, survival was not affected by the source of bacteria, whether or not a change in the pre- to post-lavage cultures occurred, whether a single bacterial isolate or multiple isolates were cultured, whether or not the patients were administered appropriate empirical antimicrobials, and whether or not a second surgery was required. Although the lack of significance for survival is likely a result of an insufficient number of cases, it could also reflect the complex nature of this disease. The cases had a wide range of clinical presentations, etiologies, treatments prior to presentation, and sources of possible contamination in addition to several other factors that cumulatively could affect the overall outcome of these patients. Intraoperative peritoneal lavage is 1 component of an overall treatment plan. Clinical parameters such as leukocyte and neutrophil counts, hematocrit, serum biochemistry abnormalities, blood pressure, heart rate, and other parameters that could help determine the severity of the clinical status of the patient were not assessed in this study which focused solely on assessing the effect of a change in bacterial culture following IOPL in clinical cases of suspected septic peritonitis.

An appropriate volume of sterile saline to be used for IOPL could not be determined in this study. Perhaps the best approach is to lavage until the fluid is clear; however, evidence to support this is lacking in the literature. In an older study, lavage with a volume of 2 to 4 L or until the fluid removed was pink or straw-colored and odorless significantly increased survival in dogs with experimentally induced septic peritonitis (33). In contrast, it is thought that localized peritonitis can become more generalized with lavage and may be ineffective against bacteria that have already adhered to the peritoneum (34,35). An experimental study that compared the infusion of a large or small diluted volume of fecal material reported a significantly greater mortality rate in dogs receiving the large volume which was thought to result from the development of generalized rather than focal peritonitis (35). Positive post-lavage culture results were obtained in 2 cases with negative pre-lavage samples in this study. It is possible that surgical manipulation and lavage resulted in release of bacteria that were either contained in a focal contaminated area or were walled off prior to surgery. However, contamination from the duodenotomy site in the case with biliary leakage culture and poor handling of the pre-lavage sample resulting in a negative culture cannot be ruled out.

Comparison of various lavage volumes with a control group was not possible in this study. Although concrete evidence to support IOPL is not available, based on widely accepted treatment recommendations it would not be ethical to have a control group that does not receive intraoperative lavage if septic peritonitis is suspected. Preoperative antimicrobials cannot be completely controlled as most dogs with septic peritonitis will have received antimicrobials from the primary care veterinarian prior to referral.

This study was not able to show whether or not IOPL significantly reduced the amount of bacteria cultured or whether it had an overall effect on survival. However, this study did identify issues that must be addressed in a larger clinic-based evaluation of peritoneal lavage in the treatment of septic peritonitis. CVJ

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