Veterinary Surgery
31:174-180, 2002

Open Peritoneal Drainage Versus Primary Closure for the Treatment of Septic Peritonitis in Dogs and Cats: 42 Cases (1993-1999)

ANDREW J. STAATZ, DVM, ERIC MONNET, DVM, PHD, Diplomate ACVS, ECVS, and HOWARD B. SEIM III, DVM, Diplomate ACVS

Objective—To determine survival rates in dogs and cats with septic peritonitis treated with open peritoneal drainage (OPD) versus primary closure (PC) after laparotomy.
Study Design—Retrospective analysis of medical records from Colorado State University Veterinary Teaching Hospital from 1993 to 1999.
Sample Population—Thirty-six dogs and 6 cats with septic peritonitis documented by cytological examination or microbiological culture of abdominal fluid.
Methods—Medical records of dogs and cats with septic peritonitis treated by OPD or PC were reviewed. Age, weight, species, white blood cell (WBC) count, band neutrophil count, platelet count, serum glucose concentration, heart rate, body temperature, duration of hospitalization, and clinical outcome were recorded for each animal. Differences in treatments administered between the OPD and PC groups as well as the underlying cause of septic peritonitis were determined.
Results—There was no significant difference in survival between animals in the OPD versus PC groups ($P = .26$) with an overall survival rate of 71%. White blood cell count, band neutrophil count, platelet count, serum glucose and total bilirubin concentrations, heart rate, age, and weight were not significantly different between groups ($P > .05$). A significantly greater number of animals in the OPD group received plasma ($P = .009$), blood ($P = .037$), and a jejunostomy tube ($P = .02$) than animals in the PC group. There was a significant difference in the number of days spent in critical care unit with a mean of 6.0 ± 4.1 days for the OPD group and 3.5 ± 2.3 days for the PC group ($P = .02$).
Conclusions—Open peritoneal drainage for the management of septic peritonitis in dogs and cats is an acceptable alternative to PC.

SEPTIC PERITONITIS, defined as the presence of bacteria in the peritoneal cavity, is recognized as a surgical emergency. Septic peritonitis is associated with a poor prognosis, especially if abdominal contamination is severe and foreign material is present.[1-9] Surgical treatment of septic peritonitis includes abdominal exploration, identifying and controlling the source of contamination, and appropriate drainage of contaminants. In addition to lavage at the time of the initial laparotomy, several methods have been used to permit postoperative drainage including Penrose drains, multiple lumen sump drains, abdominal dialysis catheters, and open peritoneal drainage (OPD).[1-4,7,9-11]

Open peritoneal drainage has been recommended for the treatment of septic peritonitis if contamination is diffuse and not readily removed during the initial

From the Department of Clinical Sciences, Colorado State University, Fort Collins, CO. Presented at the ACVS 35th Annual Scientific Meeting, Arlington, VA, September 20-23, 2000.

Address reprint requests to Eric Monnet, DVM, PhD, Department of Clinical Sciences, Colorado State University, 300 West Drake Road, Fort Collins, CO 80523.

0161-3499/02/3102-0012$35.00/0
doi:10.1053/jvet.2002.31043

Table 1. Comparison of Mean Preoperative Data (±SD) Between OPD and PC Groups and Significance of Difference Between Groups

Variable	OPD	PC	*P* Value
WBC	22.2 (±20.0)	24.5 (±14.3)	0.69
Band neutrophil	5.5 (±9.7)	2.0 (±2.0)	0.10
Platelets	172.7 (±125.8)	243.9 (±114.8)	0.20
Glucose	97.7 (±25.6)	113.3 (±59.1)	0.45
Total bilirubin	0.8 (±0.9)	1.3 (±3.1)	0.66
Age (yr)	4.27 (±3.80)	6.52 (±4.47)	0.18
Weight (kg)	20.2 (±12.6)	23.9 (±16.1)	0.56

Abbreviations: OPD, open peritoneal drainage; PC, primary closure; WBC, white blood cell.

laparotomy.[1,4,9,10,12] Open peritoneal drainage in humans has been associated with a high morbidity, specifically hypoproteinemia, nosocomial infections, and disseminated intravascular coagulation.[1] The mortality rate for dogs and cats with septic peritonitis treated with OPD has been reported to be as high as 48%.[10] Consequently, OPD has been associated with a poor prognosis and reserved for severe cases of septic peritonitis. It is unclear whether the high mortality associated with OPD is because of the technique, the underlying disease, or both. Outcome of OPD has not been compared with traditional primary closure (PC) in a similar population.

The hypothesis of this study was that dogs and cats with septic peritonitis treated with OPD would have an increased survival compared with dogs and cats treated with primary closure. The purpose of this study was to determine and then compare survival rates of dogs and cats with septic peritonitis treated with OPD versus PC.

MATERIALS AND METHODS

Medical records of dogs and cats diagnosed with septic peritonitis at Colorado State University Veterinary Teaching Hospital between 1993 and 1999 were reviewed. Inclusion criteria were septic peritonitis established by cytological examination or culture of abdominal fluid and abdominal exploratory. Dogs and cats with neoplasia as an underlying disease were excluded. Preoperative data obtained from the medical record included weight, age, white blood cell (WBC) count, band neutrophil count, platelet count, and serum glucose and total bilirubin concentrations (Table 1). These data categories were based on criteria for sepsis established by Hauptman et al.[13] Data obtained after surgery including packed cell volume (PCV), serum glucose concentration, heart rate, and total protein were also recorded (Table 2, Fig 1). Intraoperative and postoperative treatments varied from patient to patient but may have included feeding tube placement, administration of antibiotics and colloids, and treatment in the critical care unit (Table 3).

The underlying causes of septic peritonitis were grouped into one of four categories: prior abdominal surgery, gastrointestinal, hepatobiliary, and miscellaneous. The prior abdominal surgery group included animals that developed septic peritonitis as a result of a prior surgical procedure.

Table 2. Comparison of Data Collected 1 to 2 Hours Postoperatively (Mean ± SD) for Open Peritoneal Drainage (OPD) and Primary Closure (PC) Groups and Significance of Difference Between Groups

Variable	OPD	PC	*P* Value
PCV	35.4 (±6.6)	33.3 (±9.4)	0.53
Total protein	4.7 (±1.3)	4.8 (±1.0)	0.75
Glucose	88.5 (±64.3)	126.6 (±77.3)	0.52
Heart rate	144.2 (±20.6)	132.9 (±32.3)	0.43

Abbreviation: PCV, packed cell volume.

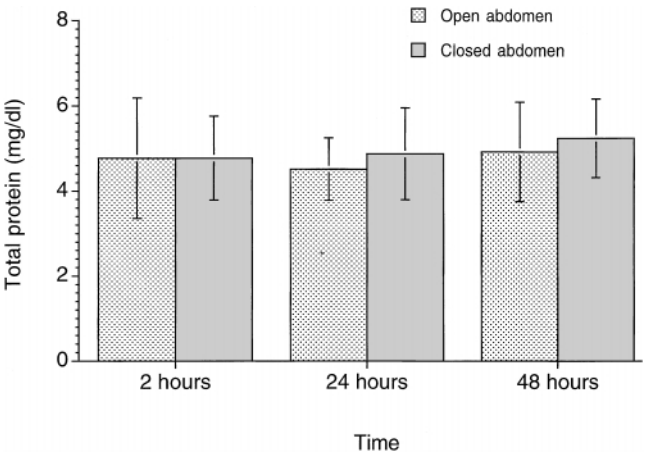

Fig 1. Bar graph comparison of total solids in animals with open peritoneal drainage versus primary closure for treatment of septic peritonitis at 2 hours postoperative, 24 hours postoperative, and 48 hours postoperative ($P = .58$).

Table 3. Comparison of Frequency of Treatments Administered Intraoperatively or Postoperatively and Duration of Hospitalization (Mean ± SD) Between OPD and PC Groups

Variable	OPD	PC	*P* Value
Jejunostomy tube placed	7/9	11/33	0.019
Plasma	6/9	6/33	0.0092
Blood	5/9	6/33	0.0376
Hetastarch	1/9	6/33	>0.99
Enrofloxacin/ampicillin	5/9	14/33	0.71
Cefoxitin	7/9	23/33	>0.99
Days in CCU*	6.0 (±4.1)	3.5 (±2.3)	0.02

* Critical care unit.

Examples include peritonitis secondary to gastrointestinal surgery (partial gastrectomy, enterotomy, intestinal resection and anastomosis, and gastrostomy tube placement) as well as elective procedures (ovariohysterectomy and exploratory laparotomy). The gastrointestinal group included animals that developed gastrointestinal perforation unassociated with prior surgery. Examples include gastrointestinal foreign bodies, intussusception, gastric dilatation and volvulus, and inflammatory bowel disease. The hepatobiliary group included patients with septic peritonitis from primary disorders of the liver or biliary tract. Examples include liver abscess, cholecystitis, and necrotizing hepatitis. Finally, patients with septic peritonitis originating from the urogenital tract or septic peritonitis of unknown origin were placed in the miscellaneous group (Table 4). Examples include pyometra and pyelonephritis.

All patients in the OPD and PC groups had an exploratory laparotomy to find the source of septic peritonitis. The source was controlled by removal or closure of the source organ followed by lavage. The animals in the PC group had their abdominal incision closed in a three-layer closure. Patients selected for OPD had 2-cm loops of 0 to No. 1 monofilament suture placed at 5-cm intervals in the external rectus sheath on either side of the abdominal incision. These loops were laced together with umbilical tape in a shoelace pattern. Multiple sterile laparotomy sponges were placed on top of the umbilical tape. This was followed by two layers of sterile surgery towels. The bandage was covered with a sterile water-impermeable adhesive drape (Steri Drape II; 3M Healthcare, St. Paul, MN). Roll gauze and conforming tape were used to cover and secure the bandage. Male dogs had a urinary catheter and closed urinary collection system placed to divert urine away from the bandages.

Postoperative abdominal lavage for animals treated by OPD was performed in the operating room with the patient under general anesthesia. One lavage was performed every 24 hours. Abdominal fluid obtained during each abdominal lavage was examined cytologically. Abdominal closure was based on cytological absence of bacteria and degenerative neutrophils in abdominal fluid as well as subjective assessment by the surgeon of gross abdominal contamination. Abdominal lavage was performed with body temperature sterile saline, which was completely aspirated after the final lavage. If the abdomen was left open for another 24 hours, a sterile bandage was applied as described previously.

Table 4. Frequency of Groups of Underlying Cause of Septic Peritonitis and Most Commonly Isolated Bacteria

Variable	OPD	PC	*P* Value
Prior surgery	3/9	11/33	>0.99
Hepatobiliary	1/9	6/33	>0.99
Gastrointestinal	4/9	12/33	>0.99
Miscellaneous*	1/9	4/33	>0.99
Staph/Strep*†	0/9	13/33	>0.038
E. coli*‡	3/9	7/33	0.6603
Clostridium§	3/9	5/33	0.3415

* Miscellaneous includes urogenital, bite wounds, unknown.
† *Staphylococcus* and *Streptcoccus* species.
‡ *Escherichia coli.*
§ *Clostridium* species.

All patients at the time of exploratory laparotomy for septic peritonitis had abdominal fluid collected for microbiological culturing. These samples were submitted to the Colorado State University Diagnostic Laboratory. If no growth was noted in 7 days, the samples were considered negative for growth.

Entry time for each case was established as the time of exploratory laparotomy for septic peritonitis. Survival time was established from medical records of clinic visits and telephone contact with the owner or referring veterinarian. The cause of death was recorded as related or unrelated to the peritonitis. Dogs or cats that died or were euthanized because of septic peritonitis were counted as death related to the peritonitis and were not censored. Animals that died from causes unrelated to septic peritonitis or that were alive or lost to follow-up were censored in the analysis.

The OPD population was compared with the PC population using an ANOVA test on preoperative and postoperative continuous variables. The discrete variables were compared between OPD and PC cases with a Fisher exact test. A Kaplan-Meier survival curve was established for the OPD and PC groups. Kaplan-Meier survival curves were also established for administration of colloids and the placement of jejunostomy tubes. Curves were compared with a log rank test. Statistical significance was set at $P < .05$.

RESULTS

Forty-two animals consisting of 36 dogs and 6 cats met the entry criteria. Seven of the 36 dogs and 2 of the 6 cats were treated with OPD with one to four lavages before final closure. The remaining 33 animals had their abdominal incisions closed primarily at the conclusion of the exploratory surgery.

Preoperative data including age, weight, WBC count, band neutrophil count, platelet count, and serum glucose and total bilirubin concentrations were not significantly different between the OPD and PC groups (see Table 1). Postoperative data including PCV, serum glucose concentration, heart rate, 2-hour postoperative total protein, 24-hour postoperative total protein, and 48-hour postoperative total protein were not significantly different between the OPD and PC groups (see Table 2). Postoperative treatment including frequency of administration of hetastarch and

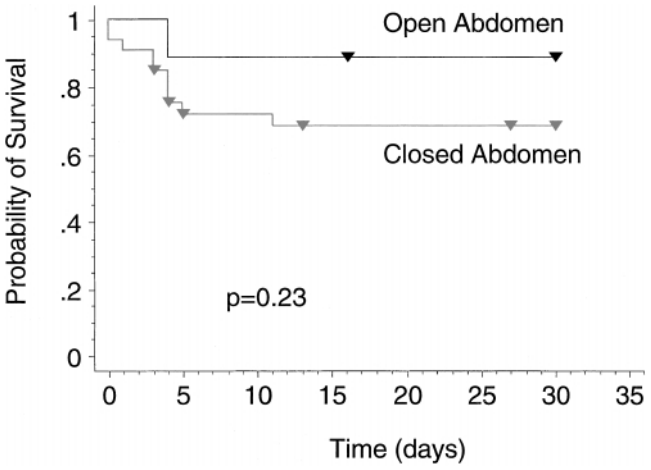

Fig 2. Cumulative survival plot comparing animals with septic peritonitis treated with open abdominal drainage versus primary closure. Censored cases are represented by triangles.

antibiotics was not significantly different between the OPD and PC group (see Table 3). Plasma and blood were administered more frequently in the OPD group compared with the PC group (see Table 3). A jejunostomy tube was placed more frequently in the OPD group than the PC group ($P = .019$). Animals in the OPD group stayed longer in the critical care unit than the animals in the PC group ($P = .02$).

There was no significant difference in the frequency of underlying cause of septic peritonitis groups between the OPD and the PC groups (see Table 4). Twenty-two different types of bacteria were isolated from septic abdomens in our study. *Escherichia coli* sp, *Clostridium* species, *Staphylococcus* sp, and *Streptococcus* sp were the only bacteria to be isolated from three or more septic abdomens (see Table 4). Consequently, only these species were selected for a limited comparison. *Staphylococcus* and *Streptococcus* were grouped together for this analysis. Other bacteria isolated were *Pseudomonas aeruginosa, Klebsiella, Proteus mirabilis, Bacteroides fragilis, Pasteurella multocida, Actinomyces, Haemophilus*, and *Enterococcus durans*. There was no significant difference in the frequency of isolation of *Escherichia coli* or *Clostridium* sp between the OPD and the PC groups. *Staphylococcus* and *Streptococcus* species were only isolated in the PC group, and this difference was significant. Interestingly, the PC animals with *Staphylococcus* or *Streptococcus* isolates had similar mortality rates as PC animals without those isolates ($P = .96$)

Five animals were lost to follow-up with a range of 3 to 16 days (median 5 days). Seven animals died of unrelated causes 5 to 616 days (median 109 days) after surgery. Ten animals from the PC group died from causes related to septic peritonitis: 3 from cardiac arrest, 2 from septic shock, 1 from disseminated intravascular coagulation, 1 was euthanatized, and 3 from unspecified causes. Evidence of septic peritonitis in these animals at the time of death is inconsistently reported. The reported cause of death in the single animal in the OPD group that died of causes related to septic peritonitis was cardiac arrest.

Overall mortality associated with septic peritonitis in this study was 29%. The 15-day and 1-year survival rate was 89% in the OPD group and 67% in the PC group. No dogs died of the consequences of peritonitis after 14 days (Fig 2). For clarity, the Kaplan-Meier survival curves have been established for 35 days follow-up. Survival between the two groups was not significantly different ($P = .23$). Regression analysis of survival versus administration of colloids to the entire study population was not significant (Fig 3). Interestingly, similar analysis of the effect of the placement of a jejunostomy tube on survival demonstrated a trend towards improved survival, although significance was not reached (Fig 4).

DISCUSSION

In this study, survival of animals with septic peritonitis after OPD was similar to that for PC. Two previous reports have studied outcomes in animals

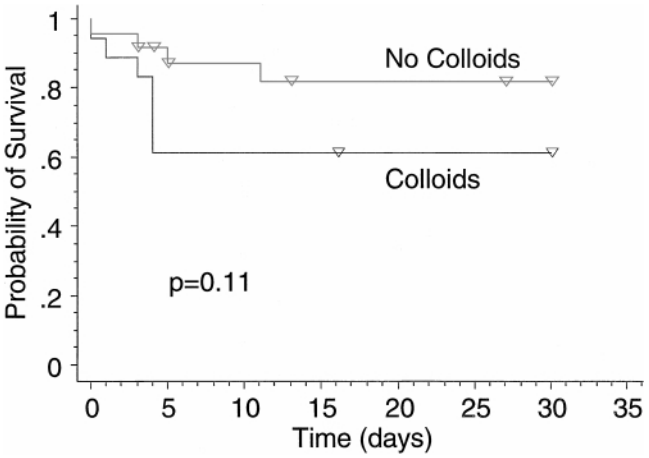

Fig 3. Cumulative survival plot comparing animals with septic peritonitis that received perioperative colloids versus those animals that did not. Censored cases are represented by triangles.

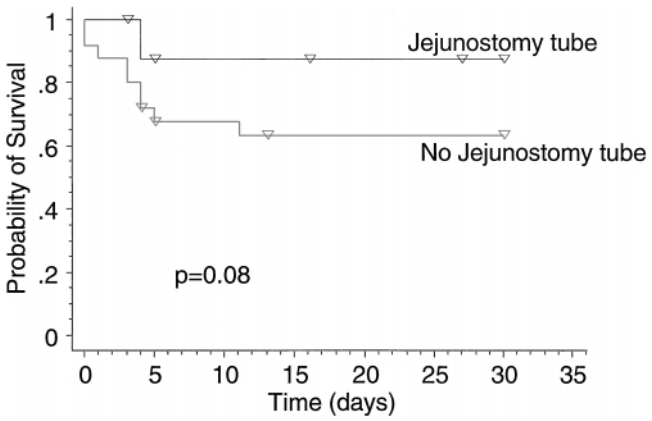

Fig 4. Cumulative survival plot comparing animals with septic peritonitis that received a jejunostomy tube versus those animals that did not. Censored cases are represented by triangles.

undergoing OPD for the treatment of septic peritonitis. Woolfson et al[10] analyzed 20 dogs and 5 cats with septic peritonitis that were treated by OPD. The overall mortality rate was 48%. Greenfield and Walshaw[9] described 22 dogs and 2 cats with septic peritonitis, also treated with OPD. Although the overall mortality was 33%, mortality directly caused by septic peritonitis was believed to be 21%. The 11% mortality obtained in our study for OPD compares favorably with these studies. Neither of these studies looked at survival of animals with septic peritonitis treated with PC.

Lanz et al[14] reported a mortality of 46% in a retrospective study of 28 dogs with septic peritonitis treated by PC. This contrasts to the 33% mortality for patients treated with PC in our study. Based on the results of our study, OPD for the treatment of septic peritonitis does not seem to be associated with as poor a prognosis as shown previously or to have a significantly different mortality rate than PC.

The retrospective nature of our study would not allow predetermination of criteria to decide which animal was treated with OPD versus PC. This decision was made by the surgeon at the time of surgery and appeared to be a subjective evaluation of the severity of contamination and inflammation. These criteria might have biased the assignment of animals with more apparently severe peritonitis to the OPD group. All surgeries were performed by a resident under the supervision of a faculty surgeon. The level of experience and supervision appeared fairly uniform. Animals treated with OPD were evenly distributed throughout the reporting period. A randomized clinical trial with established criteria would be a less biased method of selecting animals for OPD and PC groups.

Hypoproteinemia is a reported complication associated with OPD in humans and dogs.[1,7,9,10] It is believed to be caused by the loss of large volumes of protein-rich fluid during abdominal drainage. Hypoproteinemia contributes to the development of peripheral edema, depression of the immune system, delayed wound healing, and disseminated intravascular coagulation and is a risk factor for poor outcome in sepsis.[15-17] Twenty-eight percent of the animals treated with OPD in the study by Woolfson et al[10] became hypoproteinemic. In the study from Greenfield et al,[9] 12% of animals managed by OPD became hypoproteinemic. Enteral feeding was not used to support animals in these two studies. In our study, 69% animals treated with OPD were hypoproteinemic (total protein $<$ 5g/dL) during the 48 hours after surgery. However, OPD in our study was not associated with a more severe hypoproteinemia than PC (see Fig 1). Proteins are lost either in the bandage material or are accumulated in the abdominal effusion. The perception that OPD leads to the development of hypoproteinemia may have led to more aggressive treatment of the OPD group with colloids and enteral feeding.

Early and persistent enteral feeding seems to play a positive role in the recovery and outcome of septic patients.[18-21] Beyond providing nutrition, enteral feeding plays a role in maintaining the health of the gastrointestinal wall. This is associated with decreased bacterial translocation from the gastrointestinal tract and may play a significant role in the survival of septic patients.[16] Jejunostomy tubes were placed in 7 of 9 OPD dogs and cats in our study. Enteral feeding was initiated as soon as the animal was out of the surgery suite. Although there was a trend toward improved survival associated with enteral feeding in our study, significance was not reached. King[7] showed no effect of nutritional support on outcome in dogs with a septic abdomen. However, 11 of 14 dogs received parenteral nutrition. Parenteral nutrition is probably not as effective as enteral feeding in supporting the health of the intestinal wall and consequently reducing bacterial translocation.[18-21] The combined effect of enteral feeding and OPD on survival in our study would have been interesting to evaluate. Our sample population was too small, especially in the OPD group to perform this statistical test.

Ascending nosocomial infection has been recog-

nized as a complication of OPD.[1,8,10] Ten of 25 animals in the study by Woolfson et al[10] had bacterial samples taken at the time of final abdominal closure. All 10 samples were positive for growth; in addition, 7 samples matched organisms commonly encountered in their critical care unit. In the study by Greenfield et al,[9] 8 of the 10 animals that had bacterial samples taken during final closure of the abdomen were positive for microorganisms. Four of the 10 samples yielded different microorganisms than the samples obtained at the initial laparotomy, suggesting ascending contamination. Our study cultures were obtained from abdominal fluid at the time of the initial laparotomy. Cultures of abdominal fluid at the time of final closure were inconsistently performed; consequently, the true incidence of nosocomial infection in our study could not be determined. However, none of the animals in the OPD group had a reoccurrence of septic peritonitis or developed sepsis after closure. This suggests that nosocomial infection was not a factor in this population. In our study, an effort was made to minimize ascending infections by performing abdominal lavage and bandage change in a surgical suite using aseptic technique. It is the author's impression that the sterile, water-impermeable adhesive drapes used in the OPD bandages played a positive role in preventing ascending infection. This is in contrast to Greenfield et al[9] and Woolfson et al,[10] who performed sterile bandage changes on lightly sedated standing animals in the critical care unit.

The etiology of septic peritonitis varied widely in our study. The categorization of underlying causes facilitated comparison of the OPD and PC populations (see Table 4). A different set of categories may have demonstrated less similarity between the OPD and PC groups.

The inclusion or exclusion of euthanatized animals is controversial in a survival study. In this study, euthanatized animals were treated the same as animals that died due to causes related to septic peritonitis and were not censored. It can be argued that all euthanatized animals should be excluded. However, this would eliminate cases of septic peritonitis unresponsive to treatment as well as cases euthanatized for unrelated diseases. Different owners may have made different decisions and possibly influenced survival times. For similar reasons, we decided to exclude patients diagnosed with neoplasia at the time of initial surgery. Seven of eight animals identified with septic peritonitis caused by underlying neoplasia were euthanatized because of a poor prognosis due to neoplasia, not because of the severity of septic peritonitis.

Limitations of this study are the small population size and its retrospective nature. Inclusion of more cases in the future may lend more power to this study.[22]

Open peritoneal drainage with delayed abdominal wall closure is a valid technique for treatment of septic peritonitis. It is not associated with a worse prognosis or mortality rate than PC. The increased frequency of use of jejunostomy feeding tubes, perioperative administration of plasma and blood, and maintaining sterile technique during bandage changes may have contributed to the success rate of OPD in this study.

REFERENCES

1. Steinberg D: On leaving the peritoneal cavity open in acute generalized suppurative peritonitis. Am J Surg 137:216-20, 1979
2. Stone HH, Hooper CA, Millikan WJ: Abdominal drainage following appendectomy and cholecystectomy. Ann Surg 187:606-612, 1978
3. Simmermacher RKJ, Schakenraad JM, Bleichrodt RP: Reherniation after repair of the abdominal wall with expanded polytetrafluoroethylene. J Am Coll Surg 178:613-616,1984
4. Orsher RJ, Rosin E: Open peritoneal drainage in experimental peritonitis in dogs. Vet Surg 13:222-226,1984
5. Ludwig LL, McLoughlin MA, Graves TK, et al: Surgical treatment of bile peritonitis in 24 dogs and 2 cats: A retrospective study (1987-1994). Vet Surg 26:90-98, 1997
6. Hosgood G, Salisbury K: Generalized peritonitis in dogs: 50 cases (1975-1986). J Am Vet Med Assoc 193:1448-1450, 1988
7. King LG: Postoperative complications and prognostic indicators in dogs and cats with septic peritonitis: 23 cases (1989-1992). J Am Vet Med Assoc 204:407-414, 1994
8. Wylie KB, Hosgood G: Mortality and morbidity of small and large intestinal surgery in dogs and cats: 74 cases (1980-1992). J Am Anim Hosp Assoc 30:469-474, 1994
9. Greenfield CL, Walshaw R: Open peritoneal drainage for treatment of contaminated peritoneal cavity and septic peritonitis in dogs and cats: 24 cases (1980-1986). J Am Vet Med Assoc 191:100-105, 1987
10. Woolfson JM, Dulisch ML: Open abdominal drainage in the treatment of generalized peritonitis in 25 dogs and cats. Vet Surg 15:27-32, 1986
11. Willauer CC, Gregory CR, Parker HR: Treatment of peritonitis with Parker peritoneal dialysis cannula. J Am Anim Hosp Assoc 24:546-550, 1988
12. Hosgood G, Salisbury SK, Cantwell HD, et al: Intraperitoneal circulation and drainage in the dog. Vet Surg 18:261-268, 1989
13. Hauptman JG, Walshaw R, Olivier NB: Evaluation of the sensitivity and specificity of diagnostic criteria for sepsis in dogs. Vet Surg 26:393-397, 1997

14. Lanz OI, Ellison GW, Bellah JR, et al: Surgical treatment of septic peritonitis without abdominal drainage in 28 dogs. J Am Anim Hosp Assoc 37:87-92, 2001
15. Michel KE: Prognostic value of clinical nutritional assessment in canine patients. Vet Emer Crit Care 3:96-104, 1993
16. Deitch EA, Winterton J, Li M, et al: The gut as a portal of entry for bacteremia. Ann Surg 205:681-689, 1987
17. Daly JM, Vars HM, Dudrick SJ: Effects of protein depletion on strength of colonic anastomoses. Surg Gyn Obst 134:15-21, 1972
18. Thatcher CD: Nutritional needs of critically ill patients. Comp Cont Educ Pract Vet 18:1303-1313, 1996
19. Abood SK, Buffington CAT: Enteral feeding of dogs and cats: 51 cases (1989-1991). J Am Vet Med Assoc 20:619-622, 1992
20. Crowe DT Jr, Devey J, Palmer DA, et al: The use of polymeric liquid enteral diets for nutritional support in seriously ill or injured small animals: Clinical results in 200 patients. J Am Anim Hosp Assoc 33:500-508, 1997
21. Swann HM, Sweet DC, Michel K: Complications associated with use of jejunostomy tubes in dogs and cats: 40 cases (1989-1994). J Am Vet Med Assoc 210:1764-1767, 1997
22. Markel MD: The power of a statistical test. What does insignificance mean? Vet Surg 20:209-214, 1991