Retrospective Study

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Comparison of dogs with septic peritonitis: 1988–1993 versus 1999–2003

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Abstract

Objective: To describe and compare the patient population, treatment, and outcome in dogs with septic peritonitis from 2 time periods at the same institution.
Design: Retrospective study.
Setting: The Matthew J. Ryan Veterinary Hospital at the University of Pennsylvania.
Animals: Dogs treated surgically for septic peritonitis between 1988–1993 and 1999–2003.
Interventions: None.
Measurements: Preoperative physical and clinicopathologic data, surgical findings, anesthetic parameters, treatment, and outcome.
Main results: No significant difference in survival among dogs treated surgically for septic peritonitis between 1988 and 1993 (21/33 [64%]) and 1999–2003 (29/51 [57%]) was detected. The patient populations of the two time periods were similar. Changes in treatment between the study periods reflected availability of new antibiotics and synthetic colloids, as well as greater attention to pain management and ulcer prevention. Duration of hospitalization was not significantly different between the two time periods, but the daily cost adjusted to 2005 dollars was higher in 1999–2003. Potential prognostic indicators were compared between survivors and non-survivors after combining the data from both time periods, and although several parameters reached statistical significance, of greatest clinical significance were the higher blood pressure and preoperative serum albumin in survivors.
Conclusions: Although new treatments were added to the supportive care of dogs with septic peritonitis, survival did not change sufficiently to detect a significant difference between the time periods evaluated. Identifying reliable prognostic indicators for septic peritonitis remains a challenge, but hypotension and decreased preoperative serum albumin were associated with non-survival in this group of dogs.

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Keywords: abdominal surgery, septic peritonitis, small animal surgery

Introduction

Septic peritonitis represents a major cause of sepsis in dogs. Reported survival rates for dogs and cats with septic peritonitis vary. Most studies report approximately 50% survival but recent studies report 70–80% survival.[1–10] Differences in patient population and case management limit direct comparisons of survival rates from different studies. The veterinary literature reporting survival rates for septic peritonitis spans almost 20 years, and differences in treatment may occur between institutions at a given point in time. In addition, the growth of veterinary critical care is likely to impact the treatment and potentially the outcome in this group of critical patients. Previous studies often combine cats and dogs, and not every study has comparably rigorous inclusion criteria for documentation of septic peritonitis or surgical treatment.

Determining prognosis for individual patients remains challenging. Few of the many physical and laboratory findings examined have been associated with survival in cases of septic peritonitis.[3] An exhaustive evaluation in cats with septic peritonitis failed to identify routine clinical parameters associated with survival.[1] No difference in survival was detected among dogs and cats managed with open peritoneal drainage or primary closure.[5] In a study of dogs and cats managed with a closed-suction drain, survivors had higher postoperative systolic blood pressure.[6]

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The purpose of this study was to describe and compare the patient population, treatment, and outcome in dogs with septic peritonitis from two time periods at the same institution. Based on the higher survival rates reported in more recent literature[1,5,6,10] and perceived developments in treatment, we hypothesized that advances in patient care in the later time period would be associated with improved outcome endpoints, such as increased survival and shorter hospital stay, following surgery for septic peritonitis. A second aim was to identify potential prognostic indicators, both to assist in predicting outcome and to develop targeted strategies to improve survival in cases of septic peritonitis.

Materials and Methods

The medical records database was searched for canine patients between 1988–1993 and 1999–2003 matching either of the search terms 'sepsis' or 'peritonitis.' Inclusion criteria included surgical treatment and documentation of septic peritonitis by the presence of intracellular bacteria on cytologic examination or positive bacterial culture of abdominal effusion. Gross perforation of either the gastrointestinal tract or of the uterine wall in cases of pyometra was also considered adequate documentation of septic peritonitis. Dogs developing septic peritonitis during the course of hospitalization, such as following routine gastrointestinal surgery, were also included. Data recorded included patient signalment, initial physical examination and clinicopathologic data obtained by the emergency service, bacterial culture results, intraoperative findings, anesthetic parameters, treatment, intensive care unit (ICU) stay, duration of hospitalization and outcome data.

Patient characteristics, therapy, and outcome were compared between dogs treated from 1988 to 1993 and those treated from 1999 to 2003. An additional year was included in the early group due to limitations in recovering older records. Dogs alive at discharge were considered survivors, and dogs that died or were euthanized were considered non-survivors.

To determine if the dogs treated during the two time periods represented similar states of disease severity, parameters based on those used in established human and veterinary disease severity scoring systems, including the Acute Physiology and Chronic Health Evaluation (APACHE) II, Predisposition, Infection, Response, Organ Dysfunction (PIRO), and Survival Prediction Index (SPI) were individually compared.[11–13] Table 1 includes a list of the parameters that were evaluated based on data obtained on admission to the emergency service. The Survival Prediction Index 2 (SPI2) was calculated based on data obtained within 24 hours of admission to the ICU and compared between the two time periods to further assess disease severity.[14] Dogs met criteria for the Systemic Inflammatory Response Syndrome (SIRS) if they met at least two of the following four criteria: heart rate >140, respiratory rate >30, temperature $>39.2\,^{\circ}C$ ($102.5^{\circ}F$) or $<37.8\,^{\circ}C$ ($100.0^{\circ}F$), or WBC count $>19{,}000$ or <6000 cells/μL.[15]

To determine if treatment had changed over the time period evaluated, the number of dogs receiving treatments such as transfusions, antibiotics, and vasopressors during the course of their hospitalization was compared (Table 2). Time from admission to surgery data was excluded for dogs developing septic peritonitis after being hospitalized for another cause. Duration of hospitalization and cost data were also compared between the two time periods. Cost data were excluded for patients that developed septic peritonitis during the course of hospitalization due to the inability to distinguish costs attributable to the septic peritonitis and to the original cause for hospitalization. To allow for direct comparison, cost data from both time periods were adjusted to 2005 dollars using the consumer price index for all urban consumers.[a,b]

Dogs from the two time periods were combined and factors were compared between survivors and non-survivors for analysis of potential prognostic indicators. The same parameters used to assess disease severity between the two time periods were also compared between survivors and non-survivors for evaluation as potential prognostic indicators (Table 3a). Other initial parameters that were routinely measured in 1999–2003 but not 1988–1993 (Table 3b), intraoperative parameters (Table 3c), and treatment variables (Table 3d) were also evaluated for an association with survival. Hospitalization and cost data were compared between survivors and non-survivors.

Statistical Methods

To compare the two time groups to each other and to compare survivors to non-survivors, the Fisher's exact test (2×2 tables) or the χ^2 test was used for categorical variables. Continuous variables were assessed for normality using the Shapiro–Wilk *W* test. The *t*-test and the Wilcoxon rank sum test were used to compare continuous variables with normal and non-normal distributions, respectively. Categorical data are presented as frequencies and percentages, and continuous data are presented as means $\pm$ SD or medians with interquartile range for normal and non-normal distributions, respectively. All analyses were performed using commercially available statistical software[b]. Statistical significance was set at $P<0.05$.

Table 1: Parameters compared between dogs treated for septic peritonitis between 1988–1993 and 1999–2003 to assess disease severity

Disease severity parameters*	1988–1993	*n*	1999–2003	*n*	*P*-value
SPI2	0.685 ± 0.126	13	0.594 ± 0.168	26	0.1
Age (years)	6.5 ± 3.3	33	6.6 ± 3.5	51	0.9
Weight (kg)	26 ± 16	33	31 ± 14	51	0.2
Temperature (°F)	102.4 (101.3–104)	33	102.8 (101.5–103.5)	50	0.8
[°C]	[39.1 (38.5–40)]		[39.3 (38.6–39.7)]		
Heart rate (beats/min)	139 ± 37	32	143 ± 33	51	0.6
Respiratory rate (breaths/min)	38 ± 15	28	38 ± 16	41	0.8
Packed cell volume (%)	47 ± 13	33	44 ± 10	51	0.4
Total solids (g/dL)	6.6 ± 1.9	32	6.3 ± 1.5	51	0.3
Blood glucose (mg/dL)	90 (70–110)	33	101 (83–117)	50	0.1
pH	7.33 ± 0.07	10	7.37 ± 0.08	48	0.1
BE-ECF† (mmol/L)	−5.1 ± 5.7	10	−3.5 ± 5.5	47	0.4
Creatinine (mg/dL)	0.9 (0.7–1.6)	27	1.0 (0.8–1.7)	44	0.5
Albumin (g/dL)	2.3 ± 0.9	25	2.2 ± 0.7	44	0.5
Total bilirubin (mg/dL)	0.6 (0.4–1.0)	20	0.6 (0.4–1.0)	43	0.8
WBC ($\times 10^3/\mu L$)	15.3 (6.1–23.1)	25	18.1 (11.6–22.6)	45	0.6
Segmented neutrophils					
Bands‡	5 (0–45)	24	9 (0–25)	45	0.9
Platelet count ($\times 10^3/\mu L$)	131 (48–226)	10	153 (95–226)	40	0.6
Gender					
Female	15 (46%)	33	27 (53%)	51	0.7
Male	18 (55%)		24 (47%)		
Neutered	12 (36%)	33	30 (59%)	51	**0.07**
Dogs with SIRS	24 (75%)	32	37 (74%)	50	1.0
Source					
GI	21 (64%)	33	32 (63%)	51	0.9
UG	8 (24%)		10 (20%)		
HB	3 (9%)		5 (10%)		
Other/unknown	1 (3%)		4 (8%)		

Continuous variables are expressed as mean ± standard deviation or median (interquartile range). Categorical variables are expressed as the number of dogs (%) within each category. Significant *P*-values are in bold font.

*Obtained on admission to the emergency service (except SPI2).

†Base excess of extracellular fluid.

‡Ratio of segmented neutrophils to bands.

GI, gastrointestinal; UG, urogenital; HB, hepatobiliary; SPI, Survival Prediction Index; SIRS, Systemic Inflammatory Response Syndrome.

Results

Survival

Eighty-four dogs met the inclusion criteria. Twenty-one of 33 (64%) dogs survived between 1988 and 1993, and 29 of 51 (57%) dogs survived between 1999 and 2003 ($P = 0.65$). A total of 50 of 84 (60%) dogs survived surgical treatment for septic peritonitis.

Of the 12 non-survivors between 1988 and 1993, 3 died from cardiopulmonary arrest within 24 hours of surgery, 4 were euthanized during surgery, and 5 were euthanized or died for other reasons (1 each for intestinal anastomosis dehiscence, pneumonia, ARDS) or unspecified reasons ($n = 2$). Two of the 22 non-survivors between 1999 and 2003 died from cardiopulmonary arrest postoperatively, 8 were euthanized during surgery, and 12 were euthanized after surgery. Reasons for postoperative euthanasia included respiratory complications (pneumonia, ARDS, need for mechanical ventilation; $n = 5$), complications from sepsis (multiple organ failure and refractory hypotension; $n = 2$), cardiopulmonary arrest ($n = 3$), and unspecified ($n = 2$).

A total of 12 dogs were euthanized during surgery. Three dogs were euthanized due to presumptive metastases, 2 from the early group and 1 from the late group. Six dogs were euthanized due to the severity of peritonitis, 1 from the early group and 5 from the late group. One dog from the early group was euthanized due to intraoperative hypotension and oliguria. The reason for intraoperative euthanasia was undocumented in 2 cases. Excluding the cases of intraoperative euthanasia, 21 of 29 (72%) and 29 of 43 (67%) of dogs survived from the early and late groups, respectively ($P = 0.19$).

Population characteristics and disease severity

Thirty-four breeds were represented; mixed breed ($n = 14$), Rottweiler ($n = 9$), German Shepherd ($n = 7$), Golden Retriever ($n = 7$), and Labrador Retriever

Table 2: Differences in the treatment of dogs with septic peritonitis between 1988–1993 and 1999–2003

Treatment	1988–1993 $n = 33$	1999–2003 $n = 51$	*P*-value
Admission to surgery (hours)*	7 (4–20)	6 (4–22)	0.9
Anesthetic time (hours)	2.6 ± 0.8	3.3 ± 1.2	**0.001**
Surgical time (hours)	1.8 ± 0.7	2.1 ± 1.0	0.1
Total number of antibiotics	3.6 ± 1.5	3.1 ± 1.2	0.2
Ampicillin	19 (58%)	45 (88%)	**0.003**
Enrofloxacin	3 (9%)	42 (82%)	<**0.001**
Aminoglycoside	24 (73%)	6 (12%)	<**0.001**
Metronidazole	16 (49%)	24 (47%)	1.0
Cephalosporin	17 (52%)	21 (41%)	0.4
Synthetic colloid	14 (42%)	38 (75%)	**0.005**
Fresh frozen plasma	22 (67%)	39 (77%)	0.5
Packed red blood cells or whole blood	13 (39%)	19 (37%)	1.0
Dopamine†	9 (27%)	10 (20%)	0.4
Intraoperative phenylephrine	8 (24%)	18 (35%)	0.3
Vasopressors			
0–1	27 (82%)	38 (75%)	0.6
2–5	6 (18%)	13 (25%)	
H_2-antagonist	5 (15%)	34 (67%)	<**0.001**
Antiemetic	13 (39%)	23 (45%)	0.7
Analgesic	22 (67%)	51 (100%)	<**0.001**
Parenteral or enteral nutrition	8 (24%)	15 (29%)	0.8

See Table 1 legend.

*$n = 76$, excludes patients that developed septic peritonitis during the course of hospitalization.

†Range of reported rate = 2–15 μg/kg/min.

($n = 5$) were represented the most frequently. The gastrointestinal tract was the most common source of septic peritonitis ($n = 53$), followed by the urogenital ($n = 18$) and hepatobiliary ($n = 8$) systems. Numerous etiologies were represented, but the most common were gastrointestinal foreign body ($n = 18$), gastrointestinal neoplasia ($n = 11$), and pyometra ($n = 11$).

Samples of abdominal effusion were submitted for bacterial culture in 57 cases. Eleven of the 12 samples submitted strictly for aerobic culture were positive. Of the samples submitted for both aerobic and anaerobic culture ($n = 45$), 27 were positive only for aerobic bacteria, 3 were positive only for anaerobic bacteria, and 13 were positive for both types of bacteria. The most commonly isolated organisms included *Escherichia coli* ($n = 30$), *Enterococcus* spp. ($n = 17$), *Clostridium* spp. ($n = 13$), *Staphylococcus* spp. ($n = 8$), and *Enterobacter cloacae* ($n = 6$).

Of the individual parameters compared to assess disease severity, including both the data obtained on admission and the SPI2, there were no statistically significant differences between dogs from the two time periods (Table 1).

Treatment

There were no differences in time from admission to surgery or surgical time between the two time periods, but anesthetic time was longer in the later group (Table 2). There were few differences in the number of dogs receiving plasma, packed red blood cell, or whole blood transfusions or a specific drug during the two time periods examined. More dogs in the 1988–1993 group received an aminoglycoside ($P < 0.01$), whereas more dogs in the 1999–2003 group received enrofloxacin ($P < 0.01$), ampicillin ($P < 0.01$), an analgesic ($P < 0.01$), a histamine 2 receptor antagonist ($P < 0.01$), and a synthetic colloid ($P < 0.01$) (Table 2). There were no differences in the remainder of the treatment regimens compared between the two time periods (Table 2). Although there was no difference in the duration of hospitalization or length of stay in the ICU between the two time groups, the daily cost was higher for the 1999–2003 group (Table 4a).

Various forms of peritoneal drainage were utilized. Eight dogs were managed with open peritoneal drainage, 5 from the early group and 3 from the late group. Of the 63 dogs with primary closure of the peritoneal cavity, 8 dogs in the late group had a closed-suction drain placed, and 9 dogs in the early group had one of several types of drains placed (4-sump, 3-Penrose, 1-angiocath, 1-peritoneal lavage catheter). The form of drainage was undocumented in 1 case.

Prognostic indicators

There were few statistically significant differences between the combined group of survivors and the combined non-survivors among parameters evaluated for an association with survival (Tables 3a–3d). Survivors had higher initial (systolic, mean, diastolic; Table 3b) and intraoperative (mean, diastolic) blood pressure parameters than non-survivors as well as a shorter duration of intraoperative hypotension (Table 3c). Survivors also had statistically higher mean values than non-survivors for several initial clinicopathologic parameters, including packed cell volume (PCV), total solids (TS), blood pH, and serum albumin concentration (Table 3a). Survivors also had less prolongation of initial partial thromboplastin time (PTT) than non-survivors (Table 3b).

More non-survivors received a greater number of vasopressors, while more survivors received a greater number of antibiotics (Table 3d). Forty-six of 50 (92%) survivors and 19 of 34 (56%) non-survivors received either no or a single vasopressor, while 4 (8%) survivors and 15 (44%) non-survivors received at least 2 vasopressors ($P < 0.01$). The only dogs that received more than 2 vasopressors consisted of 7 non-survivors. Survivors spent more days in the hospital and in the ICU and had higher total hospital costs, but non-survivors had higher daily cost (Table 4b).

Table 3a: Disease severity parameters compared between survivors and non-survivors among dogs treated for septic peritonitis

Disease severity parameters*	Survivors	*n*	Non-survivors	*n*	*P*-value
Age (years)	6.2 ± 3.2	50	7.0 ± 3.7	34	0.3
Weight (kg)	26.6 ± 13.9	50	32.0 ± 16.0	34	0.1
Temperature (°F)	102.8 (101.6–103.8)	49	102.5 (100.4–103.6)	34	0.2
[°C]	[39.3 (38.7–39.9)]		[39.2 (38–39.8)]		
Heart rate (beats/min)	137 ± 38	49	147 ± 27	34	0.2
Respiratory rate (breaths/min)	40 ± 17	40	36 ± 12	29	0.3
Packed cell volume (%)	48 ± 11	50	42 ± 11	34	**0.02**
Total solids (g/dL)	6.7 ± 1.4	50	5.9 ± 1.9	33	**0.03**
Blood glucose (mg/dL)	98 (79–114)	49	97 (79–148)	34	0.3
pH	7.38 ± 0.06	34	7.34 ± 0.09	24	**0.03**
BE-ECF (mmol/L)	−3.3 ± 5.2	34	−4.4 ± 5.9	23	0.4
Creatinine (mg/dL)	0.9 (0.7–1.6)	43	1.0 (0.8–1.7)	28	0.4
Albumin (g/dL)	2.4 ± 0.7	41	1.9 ± 0.9	28	**<0.01**
Total bilirubin (mg/dL)	0.6 (0.4–0.8)	37	0.9 (0.3–1.8)	26	0.2
WBC ($\times 10^3/\mu L$)	18.3 (8–22.8)	41	16.7 (7.5–22.7)	29	1.0
Segmented neutrophils					
Bands	8 (0–22)	41	8 (0–45)	28	0.5
Platelet count ($\times 10^3/\mu L$)	131 (84–220)	25	180 (100–226)	25	0.8
Gender					
Female	29 (58%)	50	13 (38%)	34	0.1
Male	21 (42%)		21 (62%)		
Neutered	27 (54%)	50	15 (44%)	34	0.5
Dogs with SIRS	33 (69%)	48	28 (82%)	34	0.2
Source					
GI	28 (56%)	50	25 (74%)	34	0.1
UG	14 (28%)		4 (12%)		
HB	6 (12%)		2 (6%)		
Other/unknown	2 (4%)		3 (9%)		

See Table 1 legend.

*Obtained on admission to the emergency service. Same parameters as Table 1 (except SPI2).

Discussion

Within the confines of the method of assessment used in this study, dogs from 1988 to 1993 and 1999 to 2003 were similar with regard to disease severity. The APACHE II and SPI were developed for application to critically ill human and veterinary patients, respectively, within 24 hours of admission to an ICU. The PIRO system was developed more recently for application to septic human patients. Application of these disease severity scoring systems to human or veterinary patients on admission to the emergency room has not been validated.

Incomplete medical records and the lack of standardized data collection inherent in this retrospective study limited the assessment of disease severity. Application

Table 3b: Other admission parameters compared between survivors and non-survivors among dogs treated for septic peritonitis

Other admission parameters	Survivors	*n*	Non-survivors	*n*	*P*-value
Lactate (mmol/L)	2.4 (1.2–4.8)	27	2.9 (2.4–6.1)	16	0.1
Ionized calcium (mmol/L)	1.2 ± 0.1	28	1.1 ± 0.1	20	0.3
Alanine amino-transferase (U/L)	46 (32–135)	36	44 (30–95)	26	0.7
PT (%)	9 (0–20)	20	6 (0–22)	24	1.0
PTT (%)	20 (13–25)	20	30 (19–54)	24	**0.02**
Systolic BP (mm Hg)	121 ± 15	10	100 ± 23	17	**0.02**
Mean BP (mm Hg)	90 ± 16	10	70 ± 19	16	**0.01**
Diastolic BP (mm Hg)	73 ± 11	10	59 ± 17	17	**0.03**
Neutrophil toxic change observed	19 (46%)	41	11 (39%)	28	0.6

See Table 1 legend.

PT, prothrombin time; PTT, partial thromboplastin time; expressed as % elevation above control; BP, blood pressure; indirect only on admission.

Table 3c: Intraoperative parameters compared between survivors and non-survivors among dogs treated for septic peritonitis

Intraoperative parameters	Survivors	*n*	Non-survivors	*n*	*P*-value
Lowest temperature (°F)	97.6 (96.0–99.5)	44	97.1 (95.0–98.0)	21	0.2
[°C]	36.4 [35.6–37.5]		36.2 [35.0–36.7]		
Lowest systolic BP* (mm Hg)	85 (70–100)	50	75 (60–85)	34	0.06
Lowest mean BP (mm Hg)	60 ± 12	46	53 ± 11	32	**0.01**
Lowest diastolic BP (mm Hg)	45 (40–50)	46	35 (35–45)	32	**0.01**
Duration hypotension† (minutes)	0 (0–15)	50	15 (0–40)	33	<**0.01**
Polymicrobial culture	19 (51%)	37	8 (44%)	18	0.8
Gram status of culture		37		17	0.3
Gram positive	8 (22%)		7 (41%)		
Gram negative	16 (43%)		5 (29%)		
Mixed culture	13 (35%)		5 (29%)		

See Table 1 legend.

*Doppler measurements were recorded as systolic blood pressure.

†Time during which mean arterial pressure (direct or indirect) <60 mmHg or Doppler <90 mmHg.

BP, blood pressure; indirect and/or direct during anesthesia.

of the SPI2 to the study population provides a multivariate analysis of disease severity, but retrospective application of any disease severity score imparts a bias based on the availability of the data necessary to calculate the score. Although comparing individual parameters may not be as sensitive as a validated disease severity score in detecting differences between the patient populations, it maximizes the sample population for which data can be compared for each parameter. A statistical comparison was performed between populations for each of the individual parameters in the APACHE II, PIRO, and SPI for which data was available in an attempt to minimize bias in assessing disease severity retrospectively.

There were relatively few differences in treatment of dogs with septic peritonitis between 1988–1993 and 1999–2003, although quantitative differences in treatments may not have been detected. The trend toward enrofloxacin use in place of an aminoglycoside may reflect the perceived comparable efficacy and fewer side effects associated with enrofloxacin. Various forms of peritoneal drainage were utilized in this study, although most dogs had primary closure of the peritoneal cavity without additional drainage. Only dogs in the later years examined in this study received the current practice of using a closed-suction drain for management of septic peritonitis.

We were not able to detect a difference in survival or duration of hospitalization in dogs treated surgically for septic peritonitis between 1988–1993 and 1999–2003. It is possible that a smaller difference in survival existed than could be detected by the sample size available. However, the data refute a difference in survival of the magnitude suggested by comparison of the early[2–4,9] and more recent[1,5,6,10] literature. Specifically, the sample size of each group would have allowed detection of a 30% survival difference with a power of 0.8. Based on our results, the number of dogs required to detect a difference or confidently demonstrate no difference in

Table 3d: Treatment compared between survivors and non-survivors among dogs treated for septic peritonitis

Treatment	Survivors	*n*	Non-survivors	*n*	*P*-value
Admission to surgery (hours)	6 (4–19)	49	7 (4–35)	27	0.6
Anesthetic time (hours)	3.0 ± 1.0	50	3.1 ± 1.4	34	1.0
Surgical time (hours)	2.1 ± 0.9	50	1.9 ± 1.0	34	0.3
Total number of antibiotics	3.8 ± 1.2	50	2.6 ± 1.2	34	<**0.001**
Vasopressors					
0–1	46 (92%)	50	19 (56%)	34	<**0.001**
2–5	4 (8%)		15 (44%)		
Parenteral or enteral nutrition	17 (34%)	50	6 (18%)	34	0.1

See Table 1 legend.

Table 4a: Hospitalization and cost data for dogs treated for septic peritonitis between 1988–1993 and 1999–2003

	1988–1993	1999–2003	*P*-value
Days in hospital*	6 (3–9)	4 (2–7)	0.1
Days in ICU*	3 (2–6)	2 (1–4)	0.3
Total cost†	2876 (1849–4551)	3399 (2385–7351)	0.07
Daily cost†	533 (401–672)	1004 (714–1451)	<**0.001**

Data expressed as median (interquartile range). Significant *P*-values are in bold font.

*$n = 84$.

†$n = 76$, excludes patients that developed septic peritonitis during the course of hospitalization. Adjusted to 2005 dollars.

ICU, intensive care unit.

Table 4b: Hospitalization and cost data for survivors and non-survivors among dogs treated for septic peritonitis

	Survivors	Non-survivors	*P*-value
Days in hospital*	7 (5–9)	2 (1–4)	**<0.001**
Days in ICU*	4 (2–6)	2 (0–3)	**<0.001**
Total cost†	3804 (2798–6660)	2465 (1813–3326)	**0.005**
Daily cost†	616 (477–817)	1414 (852–1903)	**<0.001**

See Table 4a legend.
ICU, intensive care unit.

mortality would be close to 200. In order to achieve this number, data from multiple institutions would be necessary; however, this would also increase the heterogeneity of treatment and populations.

The comparable disease severity of the dogs included minimizes the heterogeneity of the patient population. Similarly, the inclusion criteria for documentation of septic peritonitis were strict. Although dogs had variable underlying diseases processes, the majority of non-survivors in this study died or were euthanized within 48 hours of surgery for complications associated with septic peritonitis rather than their underlying disease process. Thus, inability to detect improvement in survival of dogs with septic peritonitis may be attributable in part to the relatively few differences in treatment over the time period examined. Inherent in the hypothesis that survival would improve over that time period was that treatments impacting survival would have evolved and been employed.

The frequency of euthanasia, and in particular intraoperative euthanasia, in the later time period may further contribute to the lack of detectable improvement in survival. The survival rates reported in this study are comparable to previously reported survival rates, but it is difficult to tell what percentage of non-survivors reported in previous studies were euthanized and when the euthanasia occurred during the course of hospitalization. Most of the documented reasons for euthanasia in this study consisted of serious complications that are considered terminal, such as multiple organ failure, respiratory compromise requiring mechanical ventilation, and cardiopulmonary arrest. It is difficult to determine the extent to which the rising cost of treatment contributed to owners electing euthanasia. The percentage of non-survivors that were euthanized intraoperatively was similar between the two time periods, and survival was similar between the two time periods even after excluding the cases of intraoperative euthanasia. Thus, the high rate of euthanasia was unlikely to have masked an actual improvement in survival in the later time period.

Although many of the individual factors examined lacked potential prognostic value, blood pressure measurements on admission and during anesthesia may be useful prognostic indicators. Duration of anesthetic hypotension has been identified as an independent predictor of mortality in human patients undergoing non-cardiac surgery.[16] Non-survivors in this population of dogs with septic peritonitis had a longer duration of anesthetic hypotension and lower individual anesthetic blood pressure measurements than survivors. Initial blood pressure has not been previously evaluated in dogs presenting with septic peritonitis, and previous studies may have failed to identify an association between intraoperative blood pressure and survival due to their smaller sample sizes.[3,6] More survivors in this study received fewer vasopressors, suggesting that they either did not require vasopressor therapy or responded to single agent therapy, although individual response to therapy for hypotension was not evaluated in this study.

The survival benefit of a higher preoperative serum albumin concentration in dogs with septic peritonitis may be attributable to albumin's roles in maintaining colloid osmotic pressure, mediating inflammation and coagulation, and promoting wound healing,[17] including integrity of intestinal anastomoses.[18] Although hypoalbuminemia has been associated with death in some populations of critically ill dogs,[19] previous studies have failed to identify an association between survival and either preoperative[1,3,10] or lowest postoperative[3] serum albumin concentration in dogs and cats with septic peritonitis.

The significant differences in PCV, TS, pH, and PTT are of less clinical relevance since the mean values for non-survivors were within or only slightly outside of the reference ranges. The potential contribution of these parameters to a scoring system would have to be evaluated prospectively. Evaluation of these factors in a population large enough to allow multivariate analysis would also provide a more rigorous test of their potential use as prognostic indicators.

Survivors may have had the opportunity to receive a greater number of antibiotics as bacterial culture results became available during the course of hospitalization and as oral antibiotics were prescribed in place of intravenous antibiotics before hospital discharge. This interpretation is supported by the longer hospitalization stay among survivors. The higher daily cost of non-survivors likely reflects the significant expense incurred in the first day of hospitalization for stabilization and surgery coupled with the finding that, like in other studies,[6,9] non-survivors died or were euthanized soon after surgery.

In summary, while critical care has become more prevalent in the past 20 years, the mortality of septic peritonitis remains high. The inability to detect differences in mortality or duration of hospital stay reflects

the relatively small patient population and the lack of successful targeted therapy in sepsis. The use of validated scoring systems for various time points during hospitalization is important to potentially provide prognostic information and document severity of disease in acute illness. Multicenter trials are essential to enroll sufficient numbers of patients to test new interventions in septic peritonitis, therefore such scoring systems should be established and validated, particularly for use on admission and intraoperatively. The parameters identified in these patients (initial blood pressure, albumin, PCV, TS, pH, PTT, lowest intraoperative blood pressure, and duration of intraoperative hypotension) are all factors that should be considered in the development of such a scoring system. Management of these critical cases has improved, with more monitoring (blood pressure assessment) and more systematic pain management and ulcer prophylaxis, but large-scale, multicenter studies of novel therapeutic approaches are likely necessary to demonstrate significant improvement in survival in dogs with septic peritonitis.

Footnotes

[a] Bureau of Labor Statistics series CUUR0000SA0, http://www.bls.gov
[b] SAS, Version 9.1, SAS Institute, Cary, NC.

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