Original Article

Outcomes in dogs undergoing surgical correction for septic peritonitis: A retrospective study in 61 cases (2019-2022)

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Abstract

This retrospective study described clinical parameters, evaluated the chance of death (hazard ratio) and compared outcomes until hospital discharge in septic peritonitis dogs that underwent surgery in 61 cases at a single academic referral hospital population. The surgical records of 223 dogs with suspected septic peritonitis requiring surgical intervention were reviewed and a total of 61 dogs, primarily mixed breed (34.43%), with intraoperative gross lesions and cytology confirmed septic peritonitis were included in the study. The gastrointestinal tract was the most common source of septic peritonitis (52.46%). The overall survival to hospital discharge was 52.46%. Admission time until surgery, drain placements and preoperative antimicrobial selection corresponded to minimal inhibitory concentration (MIC), which did not affect survival nor median survival time (MST). However, dogs with septic peritonitis from a biliary source had 5 times higher chances of death until hospital discharge compared to non-biliary sources with MST 2.5 days vs 12 days, respectively (P = 0.032). Older dogs had 2.35 times higher chances of death than younger dogs (P = 0.037). This study suggested that specific septic peritonitis sources affect survival until hospital discharge. Meanwhile, admission time until surgery, closed abdominal drain placement and correct antimicrobial selection did not alter survival and MST. Despite advanced treatment protocols, the overall survival rate remained poor to guarded similar to previous reports.

Keywords: admission to surgery, dogs, drain, septic peritonitis, survival rate

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Introduction

Septic peritonitis is a life-threatening condition, often an emergency, which requires early hemodynamic stabilization, antimicrobials administration, surgical intervention for source control and decontaminate the peritoneum (Bentley, 2015; Dickinson *et al*., 2015; Fink *et al*., 2020). Septic peritonitis is defined by microbial contaminants entering the peritoneum which could be from the rupture of microbial-rich visceral organs or exogenous source from abdominal wall penetrations (Ragetly *et al*., 2011; Shipov *et al*., 2022). Confirmation of septic peritonitis was done by the presence of septic neutrophils and bacteria from abdominal fluid cytology, surgical or postmortem gross lesions (especially the gastrointestinal tract), or a positive bacterial culture from abdominal fluid samples intraoperatively (Grimes *et al*., 2011; Kirby, 2017). Early timing of diagnosis, stabilization of the patient and surgical intervention have been proposed in human medicine to prevent septic shock which associated with death (Boyer *et al*., 2009; Azuhata *et al*., 2014). In humans, Enterococci were commonly isolated from postoperative septic peritoneal fluids (Roehrborn *et al*., 2001), but the influence of this microorganism on mortality was still uncertain compared to yeast which has shown higher risk of postoperative deaths (Montravers *et al*., 2006). However, there were limited studies in veterinary medicine and the risk factors associated with poor outcomes in septic peritonitis dogs were still debated (Ralphs *et al*., 2003; Grimes *et al*., 2011; Barfield *et al*., 2016; Zorn *et al*., 2023). The survival rate of dogs with septic peritonitis was guard ranging from 40% to 60% and remained unchanged despite rapid diagnostic tools, newer surgical interventions that reduce time and human errors such as gastrointestinal anastomosis stapling devices, hemostatic clips, vessel sealing devices and more intensive postoperative care (Bently *et al*., 2007; Dayer *et al*., 2013; Fink *et al*., 2020; Zorn *et al*., 2023).

The aim of this retrospective study was to analyze treatment factors (including the source of septic peritonitis, time from admission to surgery, hospital stay duration, closed abdominal drain placement and correct empirical antimicrobials administration) associated with survival in dogs with septic peritonitis underwent surgical correction. The hypothesis of this study was that dogs which had non-gastrointestinal septic peritonitis source, shorter time from admission to surgery, closed abdominal drain placement and administered correct empirical antimicrobials) would less likely experience a chance of death during hospitalization. The secondary aim of the study was to identify other potential factors that affect survival probability during hospitalization in dogs with septic peritonitis.

Materials and Methods

Surgical records of suspected septic peritonitis dogs that underwent surgery at the Surgery Unit from a single academic referral veterinary hospital (Bangkok, Thailand) were screened over a period of 3.7 years (January 2019 to October 2022). In all cases, the septic peritonitis source was from the abdomen and required laparotomy. Septic peritonitis was confirmed by direct visualization of perforated visceral organs or septic contaminants during surgery with positive bacterial culture from the preoperative ultrasound-guided abdominal fluid sample. If direct visualization of septic peritonitis was questi<onable, a positive microbial culture from abdominal fluid samples collected perioperatively was used to confirm septic peritonitis. Two hundred and twenty-three surgical record cases of dogs with suspected septic peritonitis were under reviewed, of which 148 cases were excluded from lack of surgical evidence of septic peritonitis source or lack of positive bacterial culture confirmation from the intraoperative abdominal fluid. Fourteen out of 75 dogs were excluded for incomplete data leaving 61 dogs included in the study.

Data collection: Data collection included breed, sex, age, body weight, source of septic peritonitis, preoperative blood results, surgical procedure, abdominal drain placement, empirical antimicrobials administration, admission to surgery time, hospital stay and postoperative outcomes. The bacterial identification and antimicrobial sensitivity test was performed in all dogs by sampling intra-operative abdominal fluid after lavaging the peritoneum with copious amounts of warm sterile isotonic sodium chloride solution. The time delayed between hospital admission with the presence of clinical signs related to peritonitis until surgical intervention was recorded into 3 groups: less than 12 hours, between 12-24 hours or greater than 24 hours (Bush *et al*., 2016). Duration of hospital stays (after surgery to discharge/death) and postoperative morbidity were monitored for 15 days. Patients who were euthanized preoperatively and had incomplete data within 2 weeks postoperatively were excluded from the study.

Statistical analysis: Statistical analysis was performed using commercially available statistical software GraphPad Prism version 9.5 (GraphPad Software, CA, USA). Prior to test selection, data were assessed for normality using the Shapiro-Wilk test and since the majority of the variables were not normally distributed therefore the statistical analysis would be done by non-parametric tests. The median (interquartile range) was reported for continuous variables (age, body weight, blood profile parameters, duration of admission time until surgery and duration of hospital stay). Survival and non-survival groups were compared using Mann-Whitney *U* tests. The Kruskal-Wallis test was used to identify significant differences when comparing more than 2 groups. Categorical variables (antimicrobials administration corresponded to minimal inhibitory concentration (MIC) results, source of septic peritonitis, surgical correction, and drain placement) were compared between the 2 groups by Fisher exact tests. Statistical significance was set at P-value ≤ 0.05. Survival analysis was done by testing the null hypothesis that the risk of death of any factor within 15 days following surgery is the same in all groups. Kaplan-Meier curves were calculated to estimate the time to death. The Log-rank (Mantel-Cox) tests were used to assess risk factors for death. The hazard ratio (HR) of death was calculated for each variable with its

95% CI and statistical significance was made when *P*-value ≤ 0.05.

Results

The most common breed in this study was mixed breeds (n=21, 34.43%) followed by Pomeranian (n=8, 13.11%), Chihuahua (n=7, 11.48%), Shih tzu (n=7, 11.48%), Miniature Pinscher (n=3, 4.92%), Poodle (n=3, 4.92%), Thai Bangkaew (n=2, 3.28%), Pug (n=2, 3.28%), Siberian Husky (n=2, 3.28%), Yorkshire Terrier (n=2, 3.28%), Bull Terrier (n=1, 1.64%), Chow Chow (n=1, 1.64%), Labrador Retriever (n=1, 1.64%) and Miniature Schnauzer (n=1, 1.64%). There were 33 males (11 castrated, 22 intact) and 28 females (16 spayed, 12 intact). Median age was 101 months (34 to 132.5 months) and weight was 7 kg (4.02 to 13.75 kg). The overall admission to surgery time was 24 hours (5 to 112.5 hours).

Thirty-two dogs (52.46%) survived to hospital discharge, however, 29 dogs did not survive. Of the 29 dogs that did not survive, one dog died intraoperatively, three were euthanized within 24 hours after surgery and 25 died with a median hospital stay of 2.5 days (1 to 5 day) postoperatively. The reasons for euthanasia were reported as severe peritonitis with urinary bladder necrosis and adhesion with the jejunum and descending colon (n = 1), uncontrolled peritonitis with necrotic renal capsule leaked from previous surgery and necrotic left proximal ureteral obstruction (n = 1), and uncontrolled systemic inflammatory response syndrome (n = 1). A comparison of the demographic data, admission to surgery time, duration of hospital stay, and blood profile parameters between the survival and non-survival groups was reported in Table 1. No significant differences were observed in age, body weight, time from admission to surgery and all blood profile parameters between survival and non-survival dogs. The survival dogs had a median hospitalization time of 7 days (4.5 to 10 days) before discharge. Although no significant differences were found in the overall age and timing of admission until surgery, the survival dogs tend to be younger and had a shorter period of admission until surgery which would be further investigating.

Table 1 Parameters compared between survival and non-survival group after surgical correction in septic peritonitis dogs.

Parameters	**Survival (n=32)**	**Non-survival (n=29)**	**adjusted* *P*-value**
Sex			
Male	19	14	-
Castrated male	4	7	-
Intact male	15	7	-
Female	13	15	-
Spayed female	8	8	-
Intact female	5	7	-
Age (month)	65 (17-127.75)	123 (79-154.50)	0.1
Body weight (kg)	8.68 (4.78-18.25)	6.50 (4.00-10.80)	0.9
Admission time until surgery (hours)	23 (5-38)	45 (5-154)	0.9
Hospital stay (days)	7 (4.50-10.00)	2.50 (1-5)	**<0.001**
Blood profile parameters			
Hematocrit (%)	38.90 (30.60-45.20)	37.10 (30.03-45.93)	0.9
Hemoglobin (g/dL)	13.90 (10.95-15.37)	12.65 (9.90-15.90)	0.9
Platelet (x10^3/uL)	262 (179-416)	280 (133-375)	0.9
WBC (x10^3/uL)	17.14 (14.27-33.33)	23.95 (15.04-34.55)	0.9
Neutrophils (x10^3/uL)	15.43 (10.39-29.21)	19.92 (13.12-30.16)	0.9
ALT (Unit)	49.5 (25.50-129)	62 (28-160)	0.2
ALP (Unit)	130 (59.75-254.50)	328 (95-707)	0.9
BUN (mg%)	15.25 (10.20-27.98)	16.85 (11.03-39.80)	0.9
Creatinine (mg%)	0.70 (0.50-1.13)	0.60 (0.50-0.98)	0.9
Total protein (g%)	6.35 (5.50-6.83)	6 (5.05-7.08)	0.9
Albumin (g%)	2.60 (2.30-2.80)	2.40 (1.90-2.90)	0.9
Glucose (g%)	120.50 (94.50-138.75)	102.50 (78.25-120.50)	0.8

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

*Comparison of continuous variables between survival and non-survival groups was done by using Mann-Whitney-U Test with Bonferroni-Dunn adjusted P-value.

Abbreviations: WBC, white blood cell, ALT, alanine aminotransferase; ALP, alkaline phosphatase; BUN, Blood urea nitrogen.

Table 2 Source of contamination, surgical correction and drain placement for survival and non-survival dogs with septic peritonitis.

Parameters	Survival (n=32)	Non-survival (n=29)	Overall (n=61)	*P*-value
1. Source of septic peritonitis				
Gastrointestinal tract	17 (53.13%)	15 (51.72%)	32 (52.46%)	>0.999
Urinary tract	9 (28.13%)	5 (17.24%)	14 (22%)	0.372
Open abdominal wound	4 (12.50%)	2 (6.89%)	6 (9.84%)	0.674
Biliary tract	1 (3.13%)	6 (20.69%)	7 (11.47%)	**0.046**
Intraperitoneal abscess	1 (3.13%)	0 (0%)	1 (1.64%)	>0.999
Open abdominal wound + gastrointestinal tract	0 (0%)	1 (3.45%)	1 (1.64%)	0.475
2. Surgical correction				
Abdominal wall herniorrhaphy	3 (9.38%)	2 (6.89%)	5 (8.20%)	-
Cholecystectomy	1 (3.13%)	5 (15.63%)	6 (9.84%)	-
Cholecystectomy + enterotomy	0 (0%)	1 (3.45%)	1 (1.64%)	-
Cystotomy	1 (3.13%)	1 (3.45%)	2 (3.28%)	-
Enterotomy	2 (6.25%)	2 (6.89%)	4 (6.56%)	-
Enterotomy +mass/granuloma/abscess removal	1 (3.13%)	0 (0%)	1 (1.64%)	-
Enterotomy + intestinal resection and anastomosis	7 (21.87%)	9 (31.03%)	16 (26.23%)	-
Exploratory laparotomy +abdominal lavage	0 (0%)	3 (10.34%)	3 (4.92%)	-
Gastrotomy +intestinal resection and anastomosis	3 (9.39%)	0 (0%)	3 (4.92%)	-
GI tract closure (small perforation)	3 (9.38%)	2 (6.89%)	5 (8.20%)	-
Intestinal resection and anastomosis +abdominal wall herniorrhaphy	3 (9.38%)	1 (3.45%)	4 (6.56%)	-
Urinary bladder marsupialization	1 (3.13%)	1 (3.45%)	2 (3.28%)	-
Urethral anastomosis	2 (6.25%)	1 (3.45%)	3 (4.92%)	-
Urethrostomy	0 (0%)	1 (3.45%)	1 (1.64%)	-
Urinary bladder closure	2 (6.25%)	0 (0%)	2 (3.28%)	-
Urinary bladder torsion correction	1 (3.13%)	0 (0%)	1 (1.64%)	-
Urinary bladder closure +abdominal wall herniorrhaphy	2 (6.25%)	0 (0%)	2 (3.28%)	-
3. Abdominal drain placement				
Yes	18 (56.25%)	16 (55.17%)	34 (55.74%)	>0.999
No	14 (43.75%)	13 (44.83%)	27 (44.26%)	

Values represent the number of dogs for each parameter (% column per category).
Fisher's exact test was used for P-value calculation. Abbreviations: MIC, Minimal inhibitory concentration.

The majority of septic peritonitis was from the gastrointestinal tract found in 32 dogs (gastrointestinal perforation from foreign body and non-foreign body, tumors, severe strangulated and necrotic enteritis) followed by urinary system, biliary system and opened abdominal wound, respectively. One dog had a peritoneal abscess with jejunal adhesion and one dog had open abdominal wall puncture with intestinal protrusion and perforation (Table 2). An active abdominal drain was placed in 34 (55.74%) dogs, and 18 (52.94%) dogs with drains survived until hospital discharge. Hospitalization time was not affected by drain placement ($P > 0.05$). Median survival time of dogs that had drains placed after surgery was 9 days and dogs that did not have drains were 5 days, however, there were no significant differences in survival between the groups ($P = 0.7917$; Figure 1A).

Survival until hospital discharge for septic peritonitis dogs from gastrointestinal, urinary, opened abdominal wound, biliary, peritoneal abscess with jejunal adhesion and open abdominal wall puncture with intestinal protrusion and perforation was 53.13%, 28.13%, 12.50%, 3.13% and 0%, respectively (Table 2). There was no significant difference in survival between septic peritonitis dogs with specific sources compared to other sources in combination ($P > 0.05$) except for biliary sources ($P = 0.046$). Septic peritonitis dogs from non-biliary sources had 57.4% survival at hospital discharge which was significantly higher than biliary sources with MST 12 days compared to 2.5 days, respectively ($P = 0.032$; Figure 1B). The septic peritonitis dogs from biliary sources had 5 times greater risk of death (HR = 5.099, 95% CI = 1.15, 22.61).

All dogs had empirical antimicrobials administered prior to surgery. However, four samples were canceled: one dog had intraoperative death (biliary source) and three dogs were euthanized within 24 hours after surgery (2 biliary source, 1 gastrointestinal source). Results revealed 50 positive and 7 negative bacterial cultures. Thirty-one dogs with positive microbial culture results survived to hospital discharge. Empirical antimicrobials administered prior to surgery corresponded to MIC in 14 (24.56%) dogs and not corresponded to MIC in 43 (75.44%) dogs (Table 3). The overall survival rate when using correct preoperative empirical antimicrobials as later confirmed by bacterial culture and minimal inhibitory concentration (MIC) results was 64.29% (9 of 14 dogs). However, there was no significant difference in survival between the use of correct or incorrect antimicrobials corresponding to MIC results ($P = 0.9823$; Figure 1C). Table 4 shows the source and the number of dogs that survived to discharge from different microorganism isolates. The most common isolated microorganism in dogs was *Escherichia coli* (n = 13, 22.81%), followed by *Pseudomonas aeruginosa* (n = 6, 10.53%), *Enterococcus faecium* (n = 5, 8.77%), *Enterococcus faecalis* (n = 4, 7.02%), *Klebsiella pneumoniae* ssp *pneumoniae* (n = 3, 5.26%), *Serratia marcescens* (n = 3, 5.26%), *Staphylococcus pseudintermedius* (n = 3, 5.26%)

and *Streptococcus anginosus* (n = 2, 3.51%), respectively (Table 4). One dog had a mixed positive culture of *Pseudomonas aeruginosa* and *Pseudomonas fluorescens* from strangulated hernia with jejunal perforation. This dog developed severe enteritis with purulent abdominal effusion and did not survive to discharge.

Admission time to surgery was divided into 3 groups based on previous reports: within <12 hours (immediate group), 12 - 24 hours (early group) and >24 hours (delayed group) (Azuhata *et al*., 2014; Boyer *et al*., 2009; Bush *et al*., 2016). The survival proportion in the immediate group was 11 out of 18 (61.11%), 10 out of 14 (71.43%) in the early group and 11 out of 29 (37.93%) in the delayed group. However, there were no significant differences among the groups (P > 0.05). The age was divided into 2 groups; ≤ 8 years old (younger dogs) and > 8 years old (older dogs). The younger dogs had 68.97% survival rate (20 of 29 young dogs) which is significantly higher than older dogs (37.5% (12 of 32 old dogs), MST 4.63 days; P = 0.037), respectively. Older dogs had 2.35 times greater risk of death until hospital discharge than younger dogs (hazard ratio = 2.351, 95% CI = 1.090, 5.073) (Figure 1D).

Table 3 Preoperative empirical antibiotics usage and the correspondence with the bacterial culture and MIC results for survival and non-survival dogs with septic peritonitis.

Empirical antibiotics selection and usage	Survival (n=31)	Non-survival (n=26)	Overall (n=57)	*P*-value
Correspond to culture and MIC	9 (29.03%)	5 (19.23%)	14 (24.56%)	0.539
Not correspond to culture and MIC	22 (70.97%)	21 (80.77%)	43 (75.44%)	

Values represent the number of dogs for each parameter (% column per category). Fisher's exact test was used for P-value calculation.
Abbreviations: MIC, Minimal inhibitory concentration

Table 4 Microbial culture results in 57 dogs.

Species	Number of dogs	Survival to discharge	Septic peritonitis source
Gram-negative			
Acinetobacter pittii	1	0	GI
Aeromonas hydrophila / caviae	1	1	GI
Citrobacter koseri	1	0	Urinary
Elizabethkingia meningoseptica	1	1	Urinary
Escherichia coli	13	Biliary(0), GI(5), Urinary(1)	Biliary(1), GI(11), Urinary(1)
Klebsiella pneumoniae ssp *pneumoniae*	3	3	Open wound(1), Urinary(2)
Pseudomonas aeruginosa	6	GI(0), Urinary(1)	Urinary(4), GI(2)
*Pseudomonas fluorescens**	1	0	GI
Serratia marcescens	3	3	Urinary tract
Gram-positive			
Enterococcus faecalis	4	1	GI
Enterococcus faecium	5	GI(3), Urinary(1)	GI(4), Urinary(1)
Staphylococcus epidermidis	1	0	Urinary tract
*Staphylococcus gallinarum***	1	0	Open wound
*Staphylococcus haemolyticus***	1	1	GI
Staphylococcus pseudintermedius	3	3	GI(1), Open wound(1), Urinary(1)
Staphylococcus schleiferi	1	1	Open wound
Streptococcus anginosus	2	2	GI
Weissella confusa	1	0	Biliary tract
Fungal			
Candida topicalis	1	0	GI
Negative results	7	GI(3), Biliary(1)	GI(4), Biliary (3)

Numeric values represent the number of dogs for each parameter.
Denotations: GI gastrointestinal; * Co-infection with *E.coli* from the gastrointestinal source; ** Methicillin-resistant strains

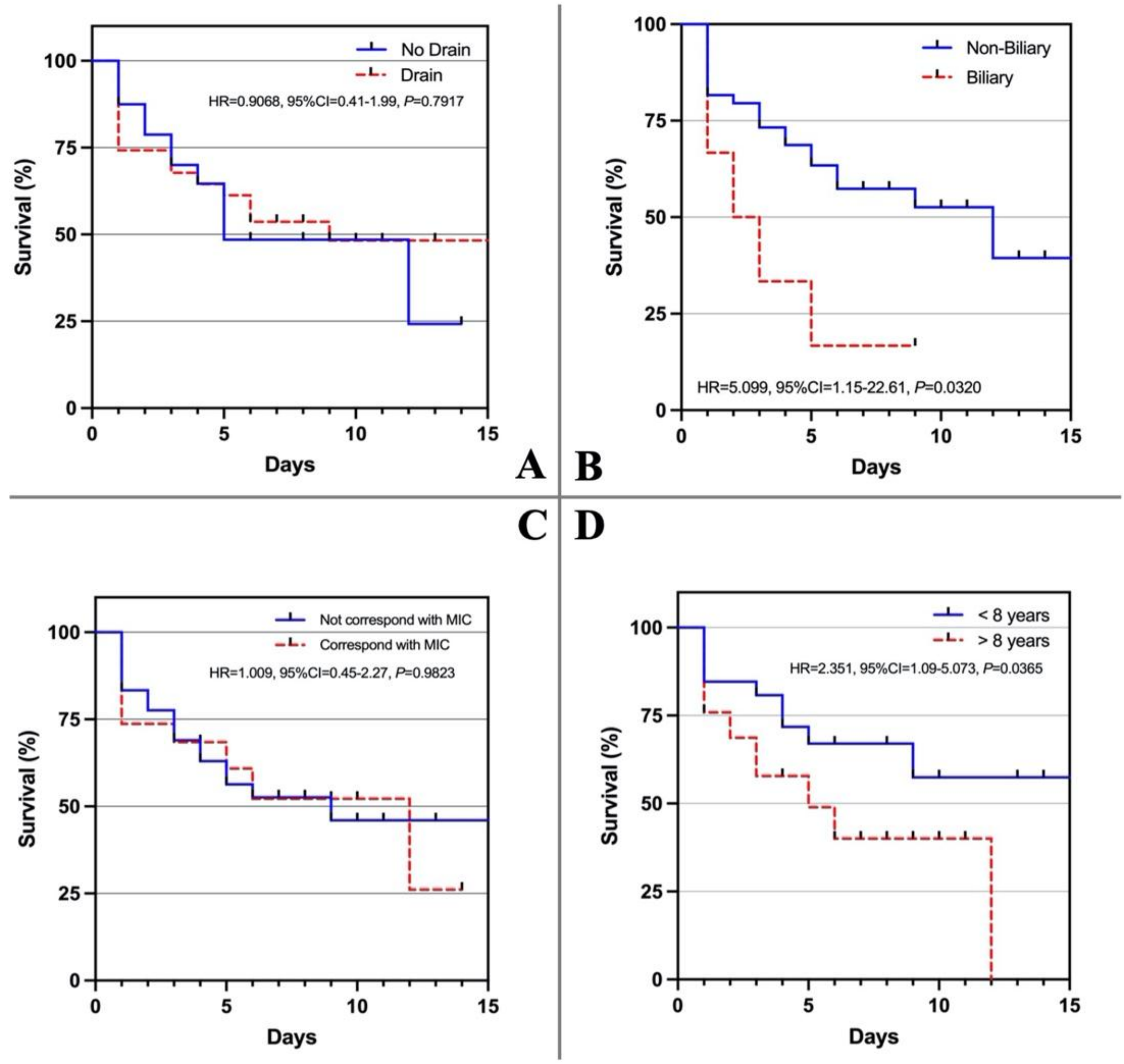

Figure 1 Kaplan-Meier survival curve represented survival rate and the median survival time to hospital discharge for 61 dogs with septic peritonitis from **(A)** drain placement (n = 34, red dash line) and without drain placement (n = 27, blue solid line), (**B**) biliary system (n = 7, red dash line) and non-biliary source (n = 54, blue solid line), **(C)** correct (n = 14, red dash line) and incorrect empirical antimicrobial usage correspond to minimum inhibitory concentrations results (n = 43, blue solid line), **(D)** older (n = 32, red dash line) and younger dogs with septic peritonitis undergoing surgery (n = 29, blue solid line).

Discussion

In this study, the survival rate of septic peritonitis dogs were poor to guarded which was similar to those in previous reports (Bentley, 2015; Dickinson *et al.*, 2015; Fink *et al.*, 2020). The most common source of abdominal contamination was gastrointestinal tract leakage (52.46%), which was consistent with other studies in cats and dogs (Scotti *et al.*, 2019; Shipov *et al.*, 2023). Although Uetsu *et al*. (2023) study found no significant difference in survival when the source of septic peritonitis occurred from different anatomical origins, however in our study, dogs with septic peritonitis from biliary sources had lower survival rate than the non-biliary sources. This finding was also stated in a study on septic shock in humans which found that biliary source was associated with higher mortality (Riché *et al.*, 2009). Surgery was mainly done to decontaminate and correct septic biliary peritonitis source from the gallbladder, cystic duct or common bile duct rupture (Jaffey *et al.*, 2018; Parkanzky *et al.*, 2019; Galley *et al.*, 2022). Bile acids contained cytotoxic agents that induced inflammation and could lead to tissue necrosis. Alteration to the peritoneal permeability occurred with septic biliary peritonitis and permitted migration of enteric organisms into the abdominal cavity resulting in a poorer prognosis (Walton, 2019). The proportion of dogs with septic biliary peritonitis were senile which was similar to Galley *et al*. (2022) with the majority being gallbladder mucocele rupture as the source of peritonitis. Preoperatively increased serum creatinine concentration and hyperphosphatemia were reported as negative prognostic factors in septic biliary peritonitis dogs (Parkanzky *et al.*, 2019). However, this study revealed that only 2 non-survival dogs had high creatinine and hyperphosphatemia. In contrast with Parkanzky *et al*. (2019), the creatinine levels in dogs in this study were low to normal range. Preoperative blood profiles were risk factors for postoperative complications after septic peritonitis surgical intervention (Ralphs *et al*., 2003; Grimes *et al*., 2011), however, preoperative blood profiles did not show a significant difference between survival and non-survival dogs.

Septic peritonitis treatment mainly focuses on correction of hemodynamic abnormalities, appropriate antimicrobial therapy and exploratory laparotomy to identify and surgically correct the cause of the peritonitis. Postoperative abdominal drainage either open or closed drainages was frequently selected by surgeons. However, the effectiveness of drainage method was still unclear in the veterinary literature for septic peritonitis treatment in dogs and cats. Previous studies suggested abdominal drainage with appropriate postoperative management was an effective treatment for peritonitis (Mueller *et al*., 2001; Adams *et al*., 2014). However, there was no statistically significant difference in survival between dogs with and without drain placement in this study. Staatz *et al*. (2004) stated similar results in survival between animals with open abdominal drainage and primary closure groups after laparotomy. A recent retrospective study in 115 septic peritonitis dogs with predominantly gastrointestinal sources showed that dogs without a closed-suction drain were three times more likely to survive than dogs with a drain. However, there was no specific protocol for drain placement choice and a drain tended to be placed in dogs with more severe, diffuse peritonitis and a large volume of peritoneal fluid found at the time of surgery (Zorn *et al*., 2023). Therefore, drain placement is a controversial issue and when chosen, it should be placed aseptically and carefully monitored during hospitalization to avoid ascending infections and postoperative complications from drains.

Broad spectrum antimicrobials, chosen presumably by the source of contamination, for empirical antimicrobials therapy were appropriate when MIC testing was not available. However, using antibiotics according to MIC results should be done whenever possible to avoid the resistance mechanism of microbial (Magréault *et al*., 2022). Surprisingly, this study and similarly studied by Kalafut *et al*. (2018) showed that appropriate versus inappropriate antimicrobial selection based on post lavage susceptibility results did not influence survival rate in septic peritonitis dogs. In addition, selecting and administrating empirical antimicrobials early in septic peritonitis diagnosed dogs showed no association with survival (Dickinson *et al*., 2015; Abelson *et al*., 2013). In this study, dogs were mostly treated with broad spectrum antimicrobials prior to surgery since the culture and MIC results were not available. The most common isolated bacteria from abdominal fluids was *Escherichia coli*, similar to the previous studies (Swayne *et al* ., 2012; Kalafut *et al*., 2018) which related to the most common gastrointestinal source of contaminants in this study. The empirical antimicrobials were administered in all suspected septic peritonitis dogs. The most commonly used broad spectrum antimicrobials were the combination of amoxicillin/clavulanic acid and metronidazole (n = 31, 29.25%), amoxicillin/clavulanic acid (n = 26, 24.53%) and metronidazole (n = 12, 11.32%). The combination of amoxicillin/clavulanic acid and metronidazole was selected when sources of septic peritonitis were suspected from the biliary system, gastrointestinal system, and opened wound (n = 4, 57.14%, n = 19, 43.18%, and n = 6, 28.57%, respectively). Amoxicillin/clavulanic acid (n = 20, 66.67%) was solely used when septic peritonitis from the urinary system was suspected.

It has been shown that delayed surgery in humans with soft-tissue infections increases the risk of mortality (Boyer *et al*., 2009). A study of septic peritonitis from gastrointestinal leakage in humans found that early goal-directed therapy combined with ≤ 6 hours early admission until surgical source control determined the survival rate (Azuhata *et al*., 2014). However, rapid diagnosis and immediate goal-directed therapy in conjunction with surgical intervention to control sources of contamination are still the cornerstone of veterinary medicine. Although early surgical intervention seems to be the ideal management for septic peritonitis cases, the concept of rapid surgical source control in veterinary medicine remained a dogma. There is a lack of evidence stating the ideal time for surgical intervention in septic peritonitis in dogs and cats. Previous studies in dogs showed no association between survival and the duration of clinical signs (Dayer *et al*., 2013), nor the time from admission to surgery (Bentley *et al*., 2015; Bush *et al*., 2016).

A study revealed that age was negatively associated with survival in septic peritonitis dogs, but the reasons remain unknown (Bush *et al*., 2016). In human literature, age has been associated with poor prognosis due to the alteration of elder immunity (Riché *et al*., 2009; Martin-Loeches *et al*., 2019). In this study, dogs > 96 months old (8 years) were associated with higher mortality and the septic peritonitis source was commonly from the gastrointestinal tract (mostly from gastrointestinal foreign body). The second most common source was the urinary system, followed by biliary system infection of which all patients were non survival from postoperative severe complications including severe sepsis and septic shock.

Due to the nature limits of the retrospective study and small sample size therefore it was not possible to draw any general conclusions from some parameter findings. Some clinical variables could not be controlled such as variation of treatment protocol managed by multiple veterinarians and surgeons, septic peritonitis source diagnosed during surgery which could influence the owner's decision for euthanasia. Moreover, the precise timing of septic peritonitis occurrence was hard to determine since the onset of clinical signs was not immediately noticed by owners or some dogs were strayed and brought in for treatment incidentally. This study was done in a single academic referral veterinary teaching hospital therefore outcomes should undoubtedly differ and careful interpretation would be needed for applying from one institution to another. Finally, this study explored data that were collected until hospital discharge, however, results might have varied if the data had been collected longer in the course of treatment and follow-up period.

In conclusion, dogs with septic peritonitis have a high mortality rate despite a shorter time of admission until surgical intervention, drain placement, antimicrobials usage corresponded to MIC results and the most common source of septic peritonitis was from gastrointestinal tract. These factors did not influence the hazard ratio in septic peritonitis dogs. Dogs with bile septic peritonitis tend to have poor to grave prognosis. Surgical intervention for septic peritonitis dogs should be done as soon as possible, however, the precise timing of surgery after hemodynamic readjustments and empirical antimicrobial therapy were still debated in veterinary medicine. Open abdominal drainage has shown no significant benefits in veterinary unlike human literature. Surgeons primarily advocated closed abdominal drainage of septic peritonitis dogs despite having an effect on MST and hospital stay. Antimicrobial usage should be administered in all cases with septic peritonitis and use antimicrobials corresponding to the MIC result when possible to prevent drug resistance. The principles of surgical intervention for septic peritonitis include hemodynamic correction, surgical source control, peritoneal lavage, and abdominal drainage. Septic peritonitis is a multifactorial condition. Further studies are needed to confirm the preoperative, intraoperative and postoperative prognostic factors to improve prognosis.

Conflicts of interest: There were no conflicts of interest that may have biased the work reported in this study.

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