The full details of the published version of the article are as follows:

TITLE: Retrospective evaluation of recurrent secondary septic peritonitis in dogs (2000–2011): 41 cases

AUTHORS: **Barfield, D. M., Tivers, M. S**., Holahan, M., Welch, K., House, A. and **Adamantos, S. E.**

JOURNAL TITLE: Journal of Veterinary Emergency and Critical Care

VOLUME/EDITION: 26

PUBLISHER: Wiley

PUBLICATION DATE: 2 November 2015 (online)

DOI: 10.1111/vec.12413

Retrospective evaluation of recurrent secondary septic peritonitis septic peritonitis in dogs (2000-2011): 41 cases

Dominic M. Barfield BSc (Hons), BVSc (Hons), MVetMed, DACVECC, MRCVS; Michael S. Tivers BVSc, PhD, DECVS, MRCVS; Matthew Holahan DVM, PhD; Kristin Welch DVM, DACVECC; Arthur House BSc, BVMS (Hons), PhD, DECVS and Sophie E. Adamantos, BVSc DACVECC, MRCVS

From the Department of Veterinary Clinical Science and Services, The Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Herts AL9 7TA, UK (Barfield, Tivers, Adamantos, House); the Department of Small Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, MI 48824, USA (Holahan) and the Department of Clinical Sciences, Tufts Cummings School of Veterinary Medicine, North Grafton, MA 01536, USA (Welch).

Dr Tivers's present address: Cave Veterinary Specialists, George Farm, West Beckland, Nr. Wellington TA21 9LE, UK.

Dr House's present address: The Veterinary Referral Hospital, Hallam, Victoria 3803, Australia.

Dr Holahan's present address: Shoreline Veterinary Referral & Emergency Center, Shelton, Connecticut 06484, USA.

Dr Welch's present address: Charleston Veterinary Referral Center, Charleston, SC 29414, USA.

Ms Adamantos's present address: Langford Veterinary Services, Langford, Bristol, BS40 5DU, UK

Address correspondence and reprint requests to

Dominic M. Barfield, Department of Veterinary Clinical Science and Services, The Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Herts AL9 7TA, UK

Email: dbarfield@rvc.ac.uk

Abstract

Objective – To describe the clinical characteristics of recurrent septic peritonitis, and to compare outcome in dogs with secondary peritonitis.

Design – Multicenter retrospective case series

Animals – Client owned dogs with recurrent septic peritonitis

Setting – Three university emergency and referral hospitals

Interventions – None

Measurements and Main Results – Medical records from 3 veterinary university teaching hospitals were reviewed and data was collected using a standardised data collection sheet for all cases of septic peritonitis during the study period (2000-2011). Forty one dogs met the inclusion criteria for recurrent peritonitis. All dogs underwent re-laparotomy. The original cause of septic peritonitis in these cases included previous surgery for gastrointestinal foreign body removal (n = 26), gastrointestinal neoplasia (n = 3), gastric or duodenal ulceration (n = 3), bilary tract leakage (n = 2), and single instance for each of the following: penetrating foreign body, hernia strangulation, intussusception, mesenteric volvulus, infection of the laparotomy incision, prostatic abscess, and trauma. Eighteen animals survived to discharge. There was no difference detected between survivors and nonsurvivors with recurrent peritonitis in terms of inciting cause, serum albumin concentration, surgical management, or provision of appropriate initial antimicrobials. The survival rate for dogs having recurrent peritonitis was 43.9% (18/41 dogs).

Conclusions – This retrospective study indicates that there is no significant prognostic indicator for dogs with tertiary peritonitis and that the mortality rate is not significantly different for dogs having more than one surgery for septic peritonitis.

Keywords: sepsis, canine.

List of Abbreviations:

MPI   Mannheim Peritonitis Index

CRP   C-reactive protein

APACHE II   Acute Physiology Score and Chronic Health Evaluation II

SPI   Survival Prediction Index

Introduction

Bacterial peritonitis has been classified as primary, secondary or tertiary. Primary or spontaneous peritonitis is infection of the peritoneal cavity with no identifiable intraperitoneal source of infection or history compatible with abdominal trauma.[1] The pathogenesis of primary bacterial peritonitis is poorly defined, although it is thought to arise from the hematogenous spread of infectious organisms. Secondary bacterial peritonitis, where there is an identifiable source of intraperitoneal infection (usually from gastrointestinal leakage), is more common than primary bacterial peritonitis. Tertiary peritonitis has previously been described as 'persistent or recurrent peritonitis' after correction of primary or secondary peritonitis.[1-5] This definition lacks consensus within the medical literature and has been described as "a therapy-resistant peritonitis with bacteria or fungi without an obvious infective focus after adequate therapy," when surgical treatment has not been successful in correcting the peritoneal infection, or a combination of both definitions. [6-10] The time period involved has also varied in medical literature from 48 hours to 7 days for this recurrence to occur following surgical source control. [6, 8, 11, 12] To the authors' knowledge there have been no comprehensive descriptions of canine tertiary peritonitis. However, due to the lack of clarity in a suitable definition of "tertiary peritonitis," we have opted to define our patients that have failed treatment for secondary septic as recurrent septic secondary peritonitis following a perceived successful surgical source control of secondary peritonitis.

To date, much of the literature on secondary peritonitis focuses on potential prognostic indicators and describe different techniques of post-operative management.[13-18] Poor prognostic indicators have been proposed but are inconsistent in the literature. Hypoproteinaemia has been suggested to be a negative prognostic indicator or a risk factor for developing septic peritonitis, but other studies have failed to corroborate this relationship.[16, 17, 19, 20] Reported mortality rates reported vary between 20 and 46%, but these may not reflect particularly different rates when the different post-operative management strategies or different study time periods are taken into consideration.[13-15, 18, 21] Moreover, it is unclear whether those dogs that died or were euthanased following treatment of secondary bacterial peritonitis had re-developed septic peritonitis.[15,18]

Relaparotomy is the treatment for tertiary peritonitis. 'On demand' (ie, re-laparotomy when the patient's condition demands it) and planned re-laparotomies (ie, re-laparotomy is performed every 36-48 hours for inspection, drainage and peritoneal lavage until the findings do not show on-going peritonitis) have been described in the human literature but these different treatment strategies are not associated with a significantly different outcome or mortality (29% on demand vs 36% for planned re-laparotomies, respectively).[22] Planned re-laparotomy, as defined in the human medicine is seldom applied in standard veterinary practice. Initial studies looking at secondary bacterial peritonitis in dogs and cats reported a mortality rate of between 48-68%. [17, 24] Although more recently the literature is suggestive that the mortality rates have improved, with rates reported between 29 and 46%, a comparison from one institution over 2 time periods did not confirm an improvement over time.[13, 14, 21, 26, 25] However, there are no mortality data specifically relating to dogs that have failed to

clear infection via surgery for secondary bacterial peritonitis in the veterinary literature. Factors that appear to govern a clinician's judgment to perform a relaparotomy include financial considerations, poor response to previous surgery, and belief that the prognosis is worse for relaparotomy of secondary bacterial peritonitis. Data in the human literature suggest that patients with higher Mannheim Peritonitis Index scores at the initial operation, increased C-reactive protein, and higher simplified Acute Physiology Score and Chronic Health Evaluation II (APACHE II) on the second postoperative day are at greater risk of recurrent or persistent septic peritonitis after adequate surgical source control[27].

Due to the lack of prognostic or survival data for dogs that have failed to clear infection via surgery for secondary bacterial peritonitis, we undertook an evaluation of outcome in these dogs in order to provide more objective information on the subject. The primary objective of this study was to describe a population of dogs that had recurrent secondary septic peritonitis (RSSP) in 3 institutions and to report the mortality rate of this population. We hypothesized that dogs with RSSP would have a similar mortality rate to the overall mortality rate for secondary septic peritonitis that has been historically published in the literature. To the authors' knowledge, this is the first study specifically examining RSSP in dogs.

Materials and Methods

Animals: All dogs admitted to the 3 institutions during the study period that had been treated for RSSP were included in this retrospective study. RSSP was defined in this study as those dogs that had persistent or recurrent septic peritonitis following adequate surgical source control for secondary bacterial peritonitis. Identification of

the persistent or recurrent secondary bacterial peritonitis was defined as those dogs that had either a positive culture from peritoneal effusion or cytological evidence of intracellular bacteria from a peritoneal fluid sample or visible evidence of continued leakage either at relaparotomy or in the management of an open abdomen. Dogs that had planned relaparotomies for the closure of open peritoneal drainage and that did not need any further surgical intervention were not included. All causes of septic peritonitis were included (eg, gastrointestinal, urogenital, hepatobiliary systems).

Data collection: The electronic medical records of all dogs evaluated at the 3 participating institutions between May 2000 and January 2011 (at institution 1, The Royal Veterinary College) and between January 2003 and December 2009 (at institutions 2 and 3, Michigan State University and Tufts Cummings School of Veterinary Medicine, respectively) were searched to identify those that were treated for RSSP. Medical records were reviewed and data were recorded using a standardized data collection sheet with information following repeat surgery, which included signalment, source of contamination, intestinal closure or anastomosis technique (ie, suture or staples), how the abdomen was managed (ie, open, closed with or without drains), biochemical parameters, microbial culture profiles (taken from abdominal fluid samples), outcome of surgery, and reason for euthanasia or cause of death (when available). Data were only analyzed for those patients that had repeat surgeries. Dogs that survived to be discharged from the hospital were considered to have had a successful outcome.

Statistical analysis

Statistical analysis was performed using a statistical software package[a]. Continuous data were assessed graphically for normality. Median and range were reported for skewed data. Continuous variables were compared with the Mann Whitney U test. Categorical data were compared with the chi square test or Fisher's exact test. Significance was set at the 5% level (P≤0.05).

Results

Number of cases from each institution

One hundred three dogs were identified as having septic peritonitis from the first institution during the study time. Twenty-nine dogs were found to have RSSP, though 9 of those dogs were euthanized prior to any further intervention. Twenty dogs were treated for RSSP at the first institution during the study period. At the second and third institutions 5 and 16 dogs, respectively, were treated for RSSP.

Patient characteristics of dogs with tertiary peritonitis

There were 41 dogs in total that met inclusion criteria from the 3 participating institutions treated for RSSP. The median age of dogs with RSSP was 5.0 years (0.7–12.0). The median age of dogs that survived was 5.3 years (range 1.0–12.0) and the median age for nonsurvivors was 5.3 years (range 0.7–12.0). There was no significant difference in the age of dogs between those that survived and those that did not (P = 0.772). Twelve dogs (29%) were male intact, 19 (46%) were male neutered, 1 (2%) was female entire, and 9 (22%) were female neutered.

The median serum albumin concentration at initial presentation was 18.8 g/L (range 9.5–39.6 g/L) reference interval 28–39 g/L (1.88 g/dL [0.95–3.96 g/dL] reference

interval 2.8-3.9 g/dL). The median serum albumin concentration for survivors was 18.1 g/L (range 9.5–29 g/L) (1.81 g/dL [range 0.95–2.9]). The median serum albumin concentration for nonsurvivors was 19.2 g/L (range 9.5–39.6 g/L) (1.92 g/dL [range 0.95–3.96]). No significant difference was detected in albumin concentration between dogs that survived and those that did not (P = 0.068). The inciting cause of the original secondary bacterial peritonitis in the 41 dogs was a gastrointestinal foreign body (which either perforated or had dehiscence following surgical removal) in 26 dogs (63.4%), gastrointestinal neoplasia in 3 dogs (7.3%), gastric or duodenal ulceration in 3 dogs (7.3%), biliary tract leakage in 2 dogs (4.9%), and 1 dog (2.4%) each: penetrating foreign body, hernia strangulation, intussusception, mesenteric volvulus, infection of the linea alba incision, prostatic abscess, and trauma. The mortality rate for the dogs with foreign bodies as their underlying cause was 50% (13/26), the mortality rate for dogs without foreign bodies was 66% (10/15). There was no difference in the mortality for dogs with foreign bodies as their underlying cause compared to those without foreign bodies (P = 0.24).

The median number of days between the original surgery for septic peritonitis and repeat surgery was 3 days (range 1–7). The median number of days in between surgeries for survivors was 3 days (range 1–7) and for nonsurvivors was 2.7 days (range 1–5). There was no difference in mortality and the number of days in between the original surgery and repeat surgery (P = 0.46). Overall, the source of the contamination was gastrointestinal in 37 dogs (90.3%), biliary tract in 2 (4.9%), prostate in 1 (2.4%), and the surgical incision in 1 (2.4%). Seven dogs (17.1%) were managed with an open abdomen at the initial surgery for recurrent peritonitis and 34 (82.9%) were managed closed (with or without a drain). Of the 37 dogs requiring

gastrointestinal surgery, staples were used for closure of the gastrointestinal tract in 5 dogs, suture material was used in 31 dogs, and in 1 dog it was not recorded. Three of the 7 dogs that were managed with an open abdomen survived. There were 15 dogs of 34 managed with a closed abdomen that survived. There was no statistically significant difference in survival for those managed open versus closed (P = 0.64). The surgical information of those patients that had more than one surgery for continued recurrent peritonitis have not been included in the results due to the small numbers that this occurred in.

Of the 41 dogs in the study, 3 dogs (7.3%) did not have samples submitted for bacterial culture during surgical correction of their continued or recurrent peritonitis. No bacterial growth was reported in 4 of 38 dogs (10.5%) from cultures submitted, of which there were 2 survivors. In the remaining 34 dogs, Escherichia coli were the predominant bacteria cultured, and other bacteria identified are reported in Table 1. Eighteen (43.9%) of the dogs with RSSP were treated with appropriate antimicrobials of which there were 8 survivors and 16 dogs (39.0%) were treated with inappropriate antimicrobials (based on bacterial sensitivity results) of which there were 7 survivors. There was no statistically significant difference in the outcome for dogs that were initially treated with appropriate versus inappropriate antimicrobials (P = 0.59). There were 2 dogs that were documented as having no visible leakage at the site of gastrointestinal repair when they were re-explored. Both of these dogs had positive bacterial cultures that were resistant to the antimicrobials that they were being treated with; in both cases their treatment was changed to an appropriate antimicrobial therapy. Of these, one patient died and the other survived to discharge.

Thirty-five dogs (85.4%) had 2 surgeries for septic peritonitis, 5 (12.2%) had 3 surgeries and 1 (2.4%) had 4 surgeries. There were 18 nonsurvivors that had 2 surgeries, 4 nonsurvivors that had 3 surgeries, and the only dog to have 4 surgeries did not survive. The median number of days that dogs were hospitalized was 9 (1–23). The median number of days of hospitalization for survivors was 9.14 (range 5–18) and for nonsurvivors was 6.67 (range 1–23). There was no statistically significant difference in the number of days of hospitalization between dogs that survived and those that did not (P = 0.082). Overall 18 dogs (43.9%) survived to discharge with the remaining 23 (56.1%) either dying as a result of their condition or from being euthanized.

Discussion

Our findings suggest that RSSP in dogs is associated with a high mortality rate (56.1%). This mortality rate is comparable to dogs that have been reported recently in the veterinary literature with secondary bacterial peritonitis (ranging from 29% to 46%).[13, 14, 21, 24, 25] Direct comparison of the mortality rate reported here with those reported elsewhere is problematic for a variety of reasons. Dogs with RSSP are, by definition, a subpopulation of those with secondary bacterial peritonitis and thus the 2 groups cannot be directly compared. Comparison with mortality rates in other studies is difficult, as some of these will include animals with RSSP in addition to many variations in the population of animals and management.

The closest equivalent in people to the population of dogs described in the present study is tertiary peritonitis. However, there is continued debate in the human medical literature as to the definition of tertiary peritonitis, with some authors suggesting that

ongoing septic peritonitis from surgical failure for source control is a different entity compared to tertiary peritonitis where no anatomical defect is identified on reexploration, while others do not make a distinction in their definition of tertiary peritonitis. [4] This debate exists despite guidelines from the International Sepsis Forum stating that tertiary peritonitis should be defined as a nosocomial infection >48 hours following treatment of secondary peritonitis.[28] We considered using a published definition of tertiary peritonitis for our population of patients with RSSP as we wanted focus on a population of secondary peritonitis where effective source control and management had occurred but failed and thus required further surgical intervention. However, in light of some authors' description, the majority of cases described in the present study could be considered as ongoing peritonitis, hence we opted to use the term RSSP. [2, 3] The important distinction that we wished to highlight was that patients described underwent surgery with effective source control for their initial secondary bacteria peritonitis; the term "ongoing peritonitis" might have been mistaken for patients in which there was no effective source control. As our study was retrospective in nature, the length of time between surgeries was not accurately measured, as the timing of the original surgery was not always documented.

Dogs that require surgical exploration within 48 hours following corrective surgery are worthy of further discussion. Although possible, it would be difficult to speculate that there would be a higher rate of potential inadequate source control, or technical failure <48 hours, compared to >48 hours in cases of RSSP. It is unclear if the inclusion of a time frame in human studies is related to these scenarios or if they are meant to account for the development of hospital acquired infections. If we chose to eliminate those 7 dogs that required surgical exploration <48 hours from corrective

surgery, this would not affect our reported mortality rate as these included 3 survivors.

The current study demonstrated that a significant proportion of dogs with secondary septic peritonitis fail to clear their infection and go on to develop RSSP. In one of the participating institutions, 29 of 103 dogs (28.2%) were affected. Nine of those 29 dogs that had persistent or recurrent sepsis after treatment were euthanized without undergoing additional surgery. The reasons for euthanasia cited in the medical record included presumption of poor prognosis for repeat surgery, concerns over underlying neoplasia, and financial constraints by the owners. If this group of animals had undergone a relaparotomy, it is possible this could have significantly altered the mortality rate in the RSSP group, but this remains unknown. In addition 3 of 41 dogs with RSSP had neoplasia as their underlying disease process. This is perhaps not surprising as dogs with incurable diseases may have been more likely to be euthanized rather than undergo repeated surgeries. Two of the 3 dogs with neoplasia were nonsurvivors, although it is unclear from the records whether they were euthanized or whether they died during hospitalization.

Our results indicate that gastrointestinal leakage secondary to foreign body ingestion (either by direct perforation or dehiscence following surgical removal) is the most common cause of RSSP in dogs (63.4%). A previous report proposed a model where dogs with 2 or more of the following: perioperative peritonitis, intestinal foreign body, and serum albumin concentration <25 g/L (<2.5 g/dL) are reasonably predicted to develop an anastomotic leak.[19] The serum albumin concentrations reported in the

present study were not significantly different between survivors and nonsurvivors and both median values were less than stipulated in the aforementioned model.

Stratification of patients based on illness severity has been previously reported in the veterinary literature. One of the more commonly use is the survival prediction index.[29] Unfortunately due to the retrospective nature of the current study, insufficient data for the majority of patients precluded use of this tool. We were also limited by the reasons for the surgical decision making; choice of materials to repair the small intestines, use of drainage etc. As in the majority of veterinary studies, the true mortality rate is extremely difficult to determine because some dogs may have been euthanized due to financial considerations and potentially a number of those animals might have survived repeat surgery. Without a standardised approach either to identify the dogs at risk as well as how they are managed intra and post-operatively, there are many potential confounding factors that might have a bearing in the outcome of the dogs described in this study.

Defining a successful outcome in this study by survival to discharge increased our sensitivity but created a potential bias. A 30- or 60-day mortality rate, as used in some studies in people could have been more specific. However, due to the retrospective nature of the study, we may have missed those patients who represented the following week and were potentially euthanized at that time. We can speculate that the majority of complications related to wound healing would have occurred prior to or during the proliferation phase (approximately 3–5 days postoperatively). That being said only 2 patients were discharged from hospital <7days (one at 5 days and one at 6 days) and it

is assumed that they were recovering well for them to have been discharged, although this cannot be confirmed.

The use of initial appropriate antimicrobials in septic peritonitis was an interesting finding, as one would expect this to be closely related to achieving a successful outcome in these dogs. However, controlling the source of contamination with copious lavage may be sufficient for successful management independent of antimicrobial choice. This supposition is supported by our findings that indicated that initial use of appropriate antimicrobials was not statistically related to survival in patients with RSSP. The retrospective nature of this study does not allow us to effectively determine if patients in whom inappropriate antimicrobials were used were switched to a different antimicrobial and whether this affected outcome. Factors that could lead to continued use of an inappropriate antimicrobial include clinical improvement regardless of antimicrobial choice or if there was a decreased breaking point of the organism in vivo (ie, the antimicrobial was at a high enough concentration in the patient to be effective as an antimicrobial, even if the population of bacteria were deemed resistant in vitro), or that the dog had been discharged or died prior to the results being obtained. We were further limited in that we encountered incomplete microbiological records for all dogs that died and therefore we are unable to ascertain the significance of appropriate antimicrobial therapy, though this warrants further evaluation.

In people it is reported that nosocomial flora are responsible for tertiary peritonitis, including *Enterococci, Pseudomonas, Enterobacter*, coagulase negative *Staphylococci* and *Candida*; however, Gram-negative bacteria (*E. coli, Klebsiella*, and

Bacteroides) have also been reported in significant numbers, with the numbers of opportunistic organisms causing an infection increasing in immunocompromised patients. [6, 27] It appears that in our study that the number of isolates was more skewed to Gram-negative infection with E. coli being the predominant microbe, although Gram-positive organisms were also highly represented. It has been reported that bacterial isolates were not predictive of either tertiary peritonitis or outcome, though age and fungal infections are risk factors for mortality. [10]

As age has been shown in people to be a factor in the development of tertiary peritonitis, it would be interesting to see if those dogs that were unsuccessful for their treatment of secondary peritonitis were older; however, it might be difficult to differentiate the role of potential comorbidities.[2, 12, 30] The mortality rate for people with tertiary peritonitis ranges from 23% to 64% and this is comparable to the rate identified in the present study. [2,8,12,31,32] However, a direct comparison between our patient population and people with tertiary peritonitis is ill advised as small intestinal perforations are less common in people and usually arise from ischemia, where obstructions are likely to arise from adhesions (83.2%) rather than bezoars (0.8%).[5,33]

In 1919, Major Hughes wrote that "the treatment for peritonitis included: removal of the cause, drainage of the peritoneal cavity, abolition of the distension, control of emesis, saline administration, and suitable nourishment." [34] Improvements in both surgical and post-operative management have changed in the last 95 years though the basic treatment has not. Although re-laparotomy for RSSP has a decreased survival compared to overall survival for septic peritonitis, it is not as poor as might be expected. This study provides invaluable information for clinicians to aid decision

making in these difficult cases. Overall, given the severity of the disease process the

mortality rate for RSSP is relatively good.

Table 1: Microbiological culture results from 38 dogs with recurrent secondary septic peritonitis

Bacteria/fungi cultured	Number of dogs with positive bacterial culture for organism (note some dogs had more than one organism cultured)
Escherichia coli	25
Enterococcus spp.	12
Enterococcus faecalis	2
Methicillin resistant *Staphylococcus aureus*	2
Enterobacter cloacae	2
Candida albicans	2
Bacteroides	2
Pseudomonas spp.	1
Streptococcus spp.	1
Clostridium spp.	1
Proteus spp.	1
Enterobacter spp.	1
Coagulation negative *Staphylococcus* spp.	1
Clostridium perfringes	1
Serratia marcesens	1
No growth	4

Footnotes

a. SPSS, version 20, SPSS, Inc, Chicago, IL.

b. Jackson-Pratt drain

References

1. Culp WTN, Zeldis TE, Reese MS and Drobatz KJ. (2009) Primary bacterial peritonitis in dogs and cats: 24 cases (1990-2006) J Am Vet Med Assoc 2009; 234(7):906-913

2. Malangoni MA Evaluation and management of tertiary peritonitis. Am Surg 2000; 66(2):157-61

3. Evans HL, Raymond DP, Shawn J et al. Tertiary peritonitis (recurrent diffuse or localized disease) is not an independent predictor of mortality in surgical patients with intrabdominal infection. Surgical Infections 2001; 2(4):255-265.

4. Mishra SP, Tiwary SK, Mishra M, et al. An introduction to tertiary peritonitis. J Emerg Trauma Shock 2014; 7(2):121–123.

5. Sartelli M. A focus on intra-abdominal infections. World J of Emerg Surg 2010; 5:9. Available at: http://www.wjes.org/content/5/1/9.

6. Panhofer P, Izay B, Riedl M, et al. Age, microbiology and prognostic scores help differentiate between secondary and tertiary peritonitis. Langenbecks Arch Surg 2009; 394(2):265–271.

7. Bujik SE, Bruining HA. Future directions in the management of tertiary peritonitis. Intensive Care Med 2002; 28(8):1024–1029.

8. Nathens AB, Rotstein OD, Marshall JC. Tertiary peritonitis: clinical features of a complex nosocomial infection. World J Surg 1998;22(2):158–163.

9. Evans HL, Raymond DP, Pelletier SJ, et al. Diagnosis of intra-abdominal infection in the critically ill patient. Curr Opin Crit Care 2001;7(2):117–121.

10. Panhofer P, Riedl M, Izay B, et al. Clinical outcome and microbial flora in patients with secondary and tertiary peritonitis. Eur Surg2007; 39(4):259–264.

11. Marshall JC, Innes M. Intensive care unit management of intra-abdominal infection. Crit Care Med 2003; 31(8):2228–2237.

12. Butler JA, Huang J, Wilson SE. Repeated laparotomy for postoperative intra-abdominal sepsis. An analysis of outcome predictors.Arch Surg 1987; 122(6):702–706.

13. Staatz AJ, Monnet E, Seim HB 3rd. Open peritoneal drainage versus primary closure for the treatment of septic peritonitis in dogs and cats: 4 cases (1993-1999). Vet Surg 2002; 31(2):174–180.

14. Mueller MG, Ludwig LL, Barton LJ. Use of closed-suction drains to treat generalized peritonitis in dogs and cats: 40 cases (1997-1999). J Am Vet Med Assoc 2001; 219(6):789–794.

15. Lanz OI, Ellison GW, Bellah JR, et al. Surgical treatment of septic peritonitis without abdominal drainage in 28 dogs. J Am Anim Hosp Assoc 2001; 37(1):87–92.

16. 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 1987; 191(1):100–105.

17. Woolfson JM, Dulisch ML. Open abdominal drainage in the treatment of generalised peritonitis in 25 dogs and cats. Vet Surg 1986;15(1):27–32.

18. Winkler KP, Greenfield CL. Potential prognostic indicators in diffuse peritonitis treated with open peritoneal drainage in the canine patient. J Vet Emerg Crit Care 2000; 10(4):259–265.

19. Ralphs SC, Jessen CR, Lipowitz AJ. Risk factors for leakage following intestinal anastomosis in dogs and cats: 115 cases (1991-2000).J Am Vet Med Assoc 2003; 223(1):73–77.

20. Shales CJ, Warren J, Anderson DM, et al. Complications following full-thickness small intestinal biopsy in 66 dogs: a retrospective study. J Small Anim Pract 2005; 46(7):317–321.

21. Bentley AM, Otto CM, Shofer FS. Comparison of dogs with septic peritonitis: 1988–1993 versus 1999–2003. J Vet Emerg Crit Care2007; 17(4):391–398.

22. van Ruler O, Mahler CW, Boer KR, et al. Comparison of on-demand vs planned relaparotomy strategy in patients with severe peritonitis: a randomized trial. J Am Med Assoc 2007; 298(8):865–872.

23. Lawson AK, Seshadri, R. Two cases of planned relaparotomy for severe peritonitis secondary to gastrointestinal pathology. J Am Anim Hosp Assoc 2007; 43:117–121.

24. Hosgood G, Salisbury SK. Generalized peritonitis in dogs: 50 cases (1975-1986). J Am Vet Med Assoc 1988; 193(11):1448–1450.

25. Costello MF, Drobatz KJ, Aronson LR, et al. Underlying cause, pathophysiologic abnormalities, and response to treatment in cats with septic peritonitis: 51 cases (1990-2001). J Am Vet Med Assoc 2004; 225(6):897–902.

26. Parsons KJ, Owen LJ, Lee K, et al. A retrospective study of surgically treated cases of septic peritonitis in the cat (2000-2007) J Small Anim Pract 2009; 50(10):518–524.

27. Chromik AM, Meiser A, Hölling J, et al. Identification of patients at risk for development of tertiary peritonitis on a surgical intensive care unit. J Gastrointest Surg 2009; 13(7):1358–1367.

28. Calandra T, Cohen J. The International Sepsis Forum Consensus Conference on Definitions of Infection in the Intensive Care Unit.Crit Care Med 2005; 33(7):1538–1548.

29. King LG, Wohl JS, Manning AM, et al. Evaluation of the survival prediction index as a model of risk stratification for clinical research in dogs admitted to intensive care units at four locations. Am J Vet Res 2001; 62(6):948–954.

30. Bohnen JM, Mustard RA, Oxholm SE, et al. APACHE II score and adominal infection. Arch Surg 1988; 123(2):225–229.

31. Christou NV, Barie PS, Dellinger EP, et al. Surgical Infection Society intra-abdominal infection study. Prospective evaluation of management techniques and outcome. Arch Surg 1993; 128(2):193–198.

32. Koperna T, Schulz F. Prognosis and treatment of peritonitis. do we need new scoring systems? Arch Surg 1996; 131(2):180–186.

33. Ghosheh B, Salameh JR. Laparoscopic approach to acute small bowel obstruction: review of 1061 cases. Surg Endosc 2007;21(11):1945–1949.

34. Hughes B. Acute diffuse peritonitis: a series of twenty-one consecutive cases. Br Med J 1919; 2(3064): 373–375.