# Risk factors for leakage following intestinal anastomosis in dogs and cats: 115 cases (1991–2000)

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**Objective**—To identify factors associated with leakage following intestinal anastomosis in dogs and cats.

**Design**—Retrospective study.

**Animals**—90 dogs and 25 cats.

**Procedure**—Medical records of all dogs and cats that underwent intestinal resection and anastomosis between 1991 and 2000 were reviewed, and information on 27 factors was recorded.

**Results**—Anastomotic leakage was identified in 13 of the 90 dogs but in none of the 25 cats. Preoperative factors significantly associated with development of anastomotic leakage in dogs included preoperative peritonitis, serum albumin concentration, a left shift, and indication for surgery (dogs with intestinal foreign bodies were more likely to have leakage than dogs that underwent surgery for any other cause). Postoperative and case management factors significantly associated with development of leakage included duration of hospitalization, supplemental alimentation, whether the dog ate the day after surgery, blood product administration, and outcome (died vs survived). Discriminant analysis was performed, and dogs with 2 or more of the following factors were predicted to develop anastomotic leakage: preoperative peritonitis, intestinal foreign body, and serum albumin concentration ≤ 2.5 g/dL. The model accurately predicted whether leakage would develop in 67 of 80 (84%) dogs.

**Conclusions and Clinical Relevance**—Results suggest that a variety of factors may be associated with development of intestinal anastomotic leakage in dogs. In particular, dogs with 2 or more of the following risk factors are predicted to be at high risk for developing anastomotic leakage: preoperative peritonitis, intestinal foreign body, and serum albumin concentration ≤ 2.5 g/dL. (*J Am Vet Med Assoc* 2003; 223:73–77)

Intestinal resection and anastomosis is regularly performed in small animal practice. Indications for intestinal resection include poor viability or perforation secondary to intestinal foreign bodies, neoplasia, strangulation because of a hernia or adhesion, intussusception, and penetrating trauma.[1] The veterinary literature has multiple studies[2-6] examining the effectiveness of various techniques for creating intestinal anastomoses but few studies analyzing risk factors for leakage following anastomosis in clinical patients. Studies[2-6] comparing inverting, everting, and appositional suture patterns in healthy animals have found differences in healing rates and risk of adhesions, but significant differences in leakage rates have not been reported.

Ensuring adequate blood supply, reducing tension, and providing for adequate apposition have traditionally been considered the most important factors in successful anastomosis of the intestine.[7] Studies[7-15] in humans and animals have identified other factors and conditions associated with leakage, including sex (with males more likely to develop leakage than females), malnutrition, preexisting peritonitis, a foreign body causing obstruction, trauma, an intra-abdominal abscess, concurrent infection, malignancy, preoperative use of corticosteroids, increased age, preoperative bowel obstruction, preoperative weight loss of > 4.5 kg (10 lb), chronic obstructive pulmonary disease, sepsis, hypertension, diabetes mellitus, and congestive heart failure. Clinicopathologic abnormalities associated with anastomotic leakage in humans and animals include high blood urea nitrogen concentration, hypoproteinemia, neutrophilia, and low serum albumin concentration (< 3.0 g/dL).[8,9,11,16-18] Operative variables reportedly associated with an increased risk for anastomotic leakage in humans and animals include long operative times, dirty or contaminated surgery, intraoperative or postoperative blood transfusions (> 2 units of packed RBCs), emergency surgery, hypovolemia, hypotension, shock, use of intra-abdominal drains, colonic resection, resection of bowel beyond the peritoneal reflection, and an American Society of Anesthesiology score of 2 or 3.[8,9,11,12,16,17,19,20] However, few studies agree as to the most important predictors of anastomotic leakage.

The purpose of the study reported here, therefore, was to identify factors associated with intestinal anastomotic leakage in dogs and cats.

## Criteria for Selection of Cases

Medical records of the University of Minnesota Veterinary Teaching Hospital were searched to identify all dogs and cats that underwent an intestinal resection and anastomosis between 1991 and 2000.

## Procedures

Records were examined, and information on the following preoperative factors was recorded: species (dog vs cat), breed, sex, age, body weight, initial complaint, duration of anorexia prior to surgery, whether steroids were administered prior to surgery, whether there was evidence of peritonitis prior to surgery, WBC count, whether there was a left shift (defined[21] as

> 1,000 band cells/µL), platelet count, serum albumin concentration, and indication for surgery. Information on the following intraoperative factors was also recorded: segment of bowel resected, surgeon (resident vs senior clinician), suture pattern used, anesthesia time, and surgery time. Finally, information on the following postoperative and case management factors was recorded: duration of hospitalization, whether the patient ate the day after surgery, whether supplemental alimentation was provided, blood products given, whether the patient died as a result of perioperative complications, whether the patient was confirmed (at surgery or necropsy) to have intestinal anastomotic leakage, and, if appropriate, how long after surgery intestinal anastomotic leakage was recognized.

**Statistical analysis**—All variables were examined for the null hypothesis of homogeneity between groups (leakage vs no leakage) by means of $\chi^2$ analysis, with a value of $P < 0.05$ considered significant. Scalar or ordinal data were also evaluated by calculation of the Spearman correlation coefficient. Forward stepwise discriminant analysis ($P$ value for inclusion, $< 0.05$; $P$ value for removal, $> 0.10$) was performed to identify a best-fit model for prediction of leakage. Fisher linear discriminant functions were used to predict outcome (leakage vs no leakage).

## Results

Ninety dogs and 25 cats met the criteria for inclusion in the study. This included all dogs and cats that underwent intestinal resection and anastomosis during the study period.

Thirteen of the 90 (14%) dogs were confirmed to have intestinal anastomotic leakage at the time of a second surgery or necropsy; none of the cats were found to have leakage. Median time from surgery to identification of anastomotic leakage was 5 days (range, 3 to 10 days). The percentage of dogs with anastomotic leakage was significantly ($P = 0.042$) higher than the percentage of cats with leakage. Because none of the cats had anastomotic leakage, potential risk factors for leakage were analyzed only for the dogs. Data for dogs and cats were then compared to identify differences between species.

**Factors associated with anastomotic leakage**—Thirty-eight dogs underwent intestinal resection and anastomosis because of a foreign body; 27 underwent intestinal resection and anastomosis because of neoplasia. The remaining dogs underwent intestinal resection and anastomosis because of an intussusception (n = 15), stricture (3), hernia (2), trauma (4), or megacolon (1). Anastomotic leakage occurred in 10 of 38 (26%) dogs that underwent intestinal resection and anastomosis because of a foreign body, but occurred in only 3 of 52 (6%) dogs that underwent intestinal resection and anastomosis for any other reason. The indication for surgery (foreign body vs any other reason) was significantly ($P = 0.007$) associated with whether anastomotic leakage occurred (yes vs no).

Information on preoperative serum albumin concentration was available for 79 of the 90 dogs, including 11 dogs with anastomotic leakage. Mean ± SD preoperative serum albumin concentration for the 11 dogs with anastomotic leakage was 2.01 ± 0.67 g/dL; mean

preoperative serum albumin concentration for the 68 dogs without anastomotic leakage was 2.78 ± 0.82 g/dL. When dogs were grouped on the basis of preoperative serum albumin concentration ≤ 2.5 g/dL versus > 2.5 g/dL, preoperative serum albumin concentration was significantly ($P = 0.001$) associated with whether anastomotic leakage occurred. Anastomotic leakage was identified in 9 of 32 (29%) dogs with preoperative serum albumin concentration ≤ 2.5 g/dL but in only 2 of 47 (4%) dogs with preoperative serum albumin concentration > 2.5 g/dL.

Dogs were considered to have peritonitis prior to surgery if results of cytologic examination of peritoneal fluid prior to surgery or comments in the surgical record were consistent with this diagnosis. If cytologic examination had not been performed prior to surgery or evidence of peritonitis was not recorded in the surgical record, dogs were presumed to not have peritonitis prior to surgery. Peritonitis was present at the time of surgery in 20 of 90 (22%) dogs. In 8 of the 20, peritonitis was a result of perforation associated with foreign bodies. In 7 of the dogs with peritonitis at the time of surgery, surgery had previously been performed by the referring veterinarian (5 because of foreign bodies, 1 because of intussusception, and 1 for unknown reasons). Three dogs had peritonitis at the time of surgery because of perforated tumors (1 with leiomyosarcoma and 2 with lymphosarcoma) and 2 because of gunshot wounds. Anastomotic leakage was confirmed in 7 of 20 (35%) dogs with preoperative peritonitis but in only 6 of 70 (9%) dogs without peritonitis. Preoperative peritonitis was significantly ($P = 0.002$) associated with development of anastomotic leakage.

A left shift (defined[21] as > 1,000 band cells/µL) was present in 24 of 80 (30%) dogs in which a CBC had been performed. Detection of a left shift was significantly ($P < 0.001$) associated with development of anastomotic leakage, which was identified in 9 of the 24 (38%) dogs with a left shift but in only 4 of the 56 (7%) dogs without a left shift.

Blood products were given to 20 of the 90 (22%) dogs during the intraoperative or postoperative period. Plasma was given to 18 dogs, and packed RBCs were given to 4 dogs (2 received both plasma and packed RBCs). Administration of blood products was significantly ($P = 0.026$) associated with development of anastomotic leakage. Leakage was identified in 7 of 20 (23%) dogs that received blood products but in only 6 of 70 (9%) dogs that did not.

Supplemental alimentation was provided to 13 dogs (6 received enteral nutrition via a nasoesophageal tube, and 7 received total parenteral nutrition). Anastomotic leakage was identified in 6 of the 13 (46%) dogs in which supplemental alimentation was provided and in 7 of the 77 (9%) dogs in which it was not provided. Provision of supplemental alimentation was significantly ($P = 0.002$) associated with development of anastomotic leakage.

Eleven of the 13 (85%) dogs that developed anastomotic leakage died, whereas only 8 of the 77 (10%) dogs that did not develop anastomotic leakage died. Development of anastomotic leakage (yes vs no) was

significantly ($P < 0.001$) associated with outcome (died vs survived).

**Comparison of dogs and cats**—The only factor that differed significantly between dogs and cats in the present study was prevalence of preoperative peritonitis. Preoperative peritonitis was identified in 20 of 90 (22%) dogs and 0 of 25 (0%) cats. These percentages were significantly ($P = 0.028$) different.

**Discriminant analysis**—All preoperative and intraoperative factors were examined by means of forward stepwise discriminant analysis to identify the model that best fit the predicted outcome of intestinal anastomotic leakage. The best-fit model included 3 factors: preoperative peritonitis, intestinal foreign body, and serum albumin concentration ($\leq 2.5$ g/dL vs $> 2.5$ g/dL). Information on all 3 of these factors was available for only 80 dogs in the present study.

In evaluating the discriminant analysis model, it was predicted that dogs with 2 or more of these risk factors (peritonitis, intestinal foreign body, and serum albumin concentration $\leq 2.5$ g/dL) would develop intestinal anastomotic leakage. Applying this to data for dogs in the present study, it was predicted that 22 dogs would develop anastomotic leakage, of which 10 (46%) actually did. In addition, it was predicted that 58 dogs would not develop anastomotic leakage, of which 57 (98%) did not. Therefore, sensitivity of the discriminant analysis model was 91% and specificity was 83%.

## Discussion

In the present study, we identified a number of pre-, intra-, and postoperative factors associated with development of intestinal anastomotic leakage in dogs. In particular, dogs with 2 or more of the following risk factors were predicted to be at high risk for developing anastomotic leakage: preoperative peritonitis, intestinal foreign body, and serum albumin concentration $\leq 2.5$ g/dL.

Dogs in the present study were significantly more likely to develop anastomotic leakage than were cats, which was not the case in previous studies.[15,18] In fact, we did not identify a single cat that underwent intestinal anastomosis during a 10-year period at our institution that developed anastomotic leakage. The standards of care for dogs and cats at our institution during the study period were presumed to be similar. Thus, our data suggest that cats may truly be less likely to develop intestinal anastomotic leakage than dogs. In examining our data, the only factor significantly different between dogs and cats was the prevalence of preoperative peritonitis. Preoperative peritonitis was identified in 20 of 90 (22%) dogs but was not identified in any of the 25 cats. Therefore, a possible explanation for the lower risk of anastomotic leakage in cats may be the lower risk of peritonitis at the time of surgery.

As with all retrospective studies, the present study had certain limitations. In particular, recording of much of the information we wanted to examine was unreliable. For instance, although information regarding many of the preoperative factors was faithfully recorded, how consistently information on intraoperative and postoperative factors was recorded was diffi-cult to evaluate. A prospective study evaluating perioperative care and its effects on morbidity and mortality rate in dogs and cats undergoing intestinal anastomosis would seem to be worthwhile.

Anastomotic leakage is 1 of the most important complications of gastrointestinal tract surgery because of the high morbidity and mortality rates associated with it.[8,10,11] In previous studies,[14,15,18,22] anastomotic leakage rates ranged from 2 to 15.7%. The leakage rate in the present study was 14%; however, this only included dogs and cats that underwent intestinal anastomosis. The mortality rate for dogs that developed leakage was disappointingly high (11/13; 85%); however, this was consistent with rates in previous studies.[14,18,23]

Preoperative peritonitis was a significant risk factor for the development of anastomotic leakage in the present study. Bacteria and inflammatory cells produce collagenases, which reduce the collagen content of the intestinal wall and impair the strength of the anastomosis.[7,24-26] In a previous experimental study[7] of intestinal anastomosis involving 181 dogs, 30% of the dogs with deliberate fecal contamination of the peritoneal cavity developed leakage, compared with 7.4% of the dogs without fecal contamination. In a clinical study,[14] dogs and cats without preoperative peritonitis were found to have a 10% leakage rate, whereas dogs and cats with peritonitis had a 26.6% leakage rate. Because of the high risk for leakage, many surgeons will avoid immediate intestinal anastomosis in human patients with generalized peritonitis and will instead perform an enterostomy or colostomy.[25,26] Enterostomies and colostomies have been evaluated in some clinical cases in dogs,[27,28] but have not found widespread use in veterinary medicine.

Dogs that underwent intestinal anastomosis because of an intestinal foreign body were significantly more likely to develop anastomotic leakage in the present study than dogs that underwent anastomosis for any other reason. This is consistent with results of previous studies[14,15] in which the presence of a foreign body increased the risk for anastomotic leakage from 13 to 27.7% and from 0 to 6%. The reasons for this higher risk are not known, but there are several possibilities. Trauma caused by the foreign body may play a role in vessel thrombosis and development of intestinal edema. The type of foreign body (eg, linear foreign bodies vs round foreign bodies) may be important, but we were not able to examine this in the present study. Alternatively, animals that have had foreign bodies long enough to warrant intestinal resection may be more debilitated because of prolonged anorexia and vomiting and may be at higher risk for these reasons.

Low serum albumin concentration was found to be a significant risk factor for anastomotic leakage in this study. Studies[8,16] in humans and rats have shown that malnutrition and peritonitis may be independent predictors of anastomotic leakage, and the mean albumin and total protein concentrations for human patients with anastomotic leakage have been shown to be significantly lower than concentrations for patients without leakage. Although a previous retrospective study[29] in dogs indicated that hypoalbuminemia was not a risk factor for leakage following intestinal biopsy,

a study[30] in rats showed that a low serum albumin concentration secondary to malnutrition was associated with a decreased rate of healing of intestinal anastomoses and a weaker repair. The cause of hypoalbuminemia in the dogs of the present study was not determined, but it was likely a result of malnutrition or loss of albumin to the gastrointestinal tract or peritoneal cavity. We attempted to quantify the duration of anorexia prior to surgery in these dogs, but these data were unreliable precluding analysis, and clear evidence of malnutrition was difficult to glean from the records.

Because of the relationship between malnutrition, immunosuppression, decreased wound healing, and anastomotic leakage in rats and humans,[8,16] one would assume that dogs that received supplemental alimentation would have a lower incidence of leakage. In fact, the opposite was true in our study. However, only 13 of 90 dogs in our study received supplemental alimentation. Although the criteria used to determine which dogs would receive supplemental alimentation were not clear, such dogs were likely selected because they were debilitated or considered to be at high risk for leakage at the time of surgery. Studies[31-33] in rats and people have shown clear benefits to early enteral feeding after intestinal anastomosis. If supplemental alimentation had been given to all high-risk patients in the present study and all patients that did not eat on the first day after surgery, it is possible that the leakage rate would have been lower.

Although blood product administration was found to be significantly associated with development of anastomotic leakage in our study, this was more likely because of the fact that blood products were given to dogs with the highest risk for complications, rather than to any effect of blood product administration itself. There is an immunosuppressive effect of whole blood transfusions in people and rats,[8,12,20] but the clinical importance of this for dogs in the present study is not known.

The discriminant analysis performed in the present study yielded some surprising results. The positive predictive value of the model was low (46%), but the negative predictive value was high (98%). Leakage developed in only 1 case in which the discriminant analysis predicted that leakage would not occur. This was a dog that underwent rectal resection because of polyps; the anastomosis leaked through the perineal incision. On the other hand, discriminant analysis predicted that leakage would develop in 22 dogs but was identified in only 10. This type of error is acceptable, because we would rather identify and treat some patients incorrectly as high risk than incorrectly identify high-risk dogs as having a low risk. Overall accuracy of the discriminant analysis was 84% (67/80), but this value is likely to be lower when the analysis is applied to another population of dogs. Nevertheless, we believe that our findings may still be clinically useful and recommend that all dogs undergoing intestinal anastomosis with 2 or more of the risk factors (preoperative peritonitis, intestinal foreign body, and serum albumin concentration ≤ 2.5 g/dL) be considered at high risk for intestinal anastomotic leakage.

There are several benefits to identifying dogs at high risk for developing anastomotic leakage. First, such information allows veterinarians to give owners a more accurate prognosis and better estimate of anticipated costs, because dogs at high risk for anastomotic leakage are likely to have higher morbidity and mortality rates. Second, such information allows us to more aggressively treat dogs at high risk for leakage. The present study was not designed to identify factors that would improve the perioperative care of dogs at high risk for anastomotic leakage. However, we believe that at a minimum, such dogs should receive supplemental alimentation, preferably as enteral nutrition. There is evidence to suggest that even with postoperative ileus, enteral or microenteral feeding is still the best mode of nutrition in these patients.[34] Enteral feeding preserves or increases gastrointestinal tract blood flow, prevents ulceration, increases IgA concentrations, stimulates other immune system defenses, and stimulates wound repair.[31,32,34] Withholding enteral nutrition because of recent intestinal anastomosis appears to be unjustified.[31-34]

Treatment of dogs at a high risk for anastomotic leakage should also include appropriate antimicrobial administration; appropriate fluid therapy, including administration of colloids if needed for circulatory support; and close monitoring for signs of anastomotic leakage. Results of abdominocentesis are difficult to interpret in patients with preoperative septic peritonitis, but changes evident in serial samples may be useful. Subjectively, we believe the mortality rate for dogs with anastomotic leakage would have been lower if we had performed follow-up laparotomies sooner.

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