

# The incidence of surgical site dehiscence following full-thickness gastrointestinal biopsy in dogs and cats and associated risk factors

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**OBJECTIVES:** The objectives of this study were to: (1) document the incidence of surgical site dehiscence after full-thickness gastrointestinal biopsy in dogs and cats and (2) identify potential risk factors.

**METHODS:** Data relating to dogs and cats undergoing full-thickness gastrointestinal biopsy were reviewed retrospectively following submission of a completed questionnaire by 12 referral institutions. Outcome measures were definite dehiscence, possible dehiscence (clinical records suggestive of dehiscence but not confirmed), suspected dehiscence (definite and possible combined) and death within 14 days. Logistic regression was planned for analysis of association of dehiscence with low preoperative serum albumin, biopsy through neoplastic tissue, biopsy alongside another major abdominal surgical procedure and biopsy of the colon.

**RESULTS:** Of 172 cats, two (1.2%) had definite dehiscence, and four (2.3%) had possible dehiscence. Low preoperative serum albumin was significantly associated with definite dehiscence in univariable analysis and with suspected dehiscence and death within 14 days in univariable analysis, but all odds ratios had wide 95% confidence intervals. A histopathological diagnosis of neoplasia was significantly associated with death within 14 days in univariable analysis. Of 195 dogs, two (1.0%) had definite dehiscence, and

three (1.5%) had possible dehiscence. In dogs, there was no association between any outcome measure and the putative risk factors.

**CLINICAL SIGNIFICANCE:** Incidence of dehiscence following full-thickness gastrointestinal biopsy was low in this study. When determining the appropriateness of biopsy in individual cases, this information should be balanced against the potentially life-threatening consequences of dehiscence.

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## INTRODUCTION

Gastrointestinal biopsies are commonly performed as part of the diagnostic investigation of chronic gastrointestinal disease in small animal veterinary medicine. Chronic enteropathies of the dog and cat typically have non-specific clinical presentations and imaging findings (Hall & Day 2017). It is therefore often necessary to obtain a tissue sample for histopathological analysis in order to reach a definitive diagnosis and subsequently provide an appropriate treatment plan and prognosis. Gastrointestinal biopsies can either be obtained endoscopically or surgically, and there are specific advantages and limitations associated with each of these techniques (Hall 1994). Whilst obtaining an endoscopic gastrointestinal biopsy is a minimally invasive procedure with rapid recovery times, there are limitations to the size, depth and location of the biopsy sample that can be obtained via this method; tissue quality can vary, and patient preparation is required (Hall 1994, Willard *et al.* 2001, Jergens *et al.* 2016). A full-thickness surgical gastrointestinal biopsy provides a sample consisting of all layers of the gastrointestinal tract for analysis and can be obtained from any location along the tract. However, there are prolonged recovery times associated with surgery and potential morbidities that are highly unlikely to be encountered following endoscopic biopsy. The most significant morbidity associated with full-thickness incision of the gastrointestinal tract is the potential for post-operative intestinal dehiscence and ensuing septic peritonitis (Allen *et al.* 1992, Wylie & Hosgood 1994). Mortality rates of approximately 50% are consistently reported in dogs and cats with septic peritonitis that are managed appropriately with prompt surgical intervention (King 1994, Lanz *et al.* 2001, Parsons *et al.* 2009). The high likelihood of a fatal outcome if dehiscence of a surgical biopsy site were to occur necessitates careful case selection along with appropriate preoperative discussion with the client in order to obtain informed consent in light of the potential risks.

Reported complication rates following intestinal surgery differ for dogs and cats. In the cat, a study investigating the prevalence of histological abnormalities in 300 cats undergoing full-thickness surgical gastrointestinal biopsies for the investigation of suspected chronic small bowel disease reported a full recovery in all cats with no surgical site dehiscence (Norsworthy *et al.*

2015). In another study evaluating dehiscence in 70 cats with alimentary lymphoma undergoing full-thickness gastrointestinal surgery, 11 of which were considered hypoalbuminaemic preoperatively, none of the cats experienced post-operative dehiscence, and consequently, risk factors for dehiscence could not be identified (Smith *et al.* 2011). In contrast, the incidence of dehiscence following gastrointestinal surgery in dogs has been reported to be 12% following small intestinal biopsy (Shales *et al.* 2005) and 6 to 15% following small intestinal enterotomy or anastomosis (Allen *et al.* 1992, Wylie & Hosgood 1994, Ralphs *et al.* 2003, Mouat *et al.* 2014). A recent study reported a 0% rate of intestinal dehiscence following full-thickness surgical intestinal biopsy in both dogs and cats (Mitterman *et al.* 2016). Proposed risk factors for dehiscence following gastrointestinal surgery in dogs include preoperative peritonitis, preoperative hypoalbuminaemia and intraoperative hypotension, although the findings are often conflicting (Harvey 1990, Allen *et al.* 1992, Ralphs *et al.* 2003, Grimes *et al.* 2011, Snowdon *et al.* 2016). One study concluded that dogs and cats undergoing more than one intestinal surgical procedure were less likely to survive (Wylie & Hosgood 1994). This finding, combined with the proposal of intra-operative hypotension as a possible risk factor for dehiscence, suggests that undertaking multiple surgical procedures under protracted general anaesthesia may increase the risk of complications such as dehiscence. A study investigating risk factors for dehiscence of stapled enterectomy in dogs reported greater odds of dehiscence in anastomoses involving the large intestine, although case numbers were small (Snowdon *et al.* 2016). Neoplasia is a catabolic state and may have an effect on anabolic processes such as tissue healing. This raises the possibility of an increased risk of dehiscence when a full-thickness incision is made in the intestinal tract in the presence of neoplasia. However, there is no evidence to date to suggest that neoplasia influences intestinal healing in veterinary medicine (Smith *et al.* 2011).

The primary aim of this study was to document the incidence of surgical site dehiscence after a full-thickness gastrointestinal biopsy in a large population of dogs and cats. The second aim was to investigate the association between the following pre-specified risk factors and dehiscence: low preoperative serum albumin, biopsy through neoplastic tissue, biopsy alongside another major abdominal surgical procedure and biopsy of the colon.

## MATERIALS AND METHODS

Clinical data from 12 UK small animal referral hospitals (both private and university) were collected during the study period (January 2004 to December 2014). The data were anonymously reviewed. Ethical approval was obtained from an institutional ethics committee prior to data collection.

A data table template was submitted to each institution along with explanatory guidelines for completion. Inclusion criteria were all dogs and cats undergoing full-thickness gastrointestinal biopsy during the study period, with sufficient clinical records to complete the data table and a minimum of 14 days clinical follow-up. Dogs and cats were excluded from the study if they had preexisting septic peritonitis (see definition below). Information obtained from the clinical records of each case included case identification, signalment, preoperative serum albumin concentration (including reference ranges), date of gastrointestinal biopsy, location and number of gastrointestinal biopsies, histopathological diagnosis and documentation of any abdominal surgical procedures performed under the same general anaesthesia as the gastrointestinal biopsies. Post-operative complications were recorded as a free-text description. If post-operative gastrointestinal dehiscence occurred, then the timing, method of diagnosis and identified cause were recorded where known. Once completed, the data table from each centre was submitted to an administrator, who was not involved in data analysis. Each centre was anonymised via a simple coding system known only to the administrator. The coded data were then forwarded for analysis.

The complications data were used to determine the two outcome measures used, namely whether dehiscence (*definite* dehiscence yes/no) or patient death from any cause (dead yes/no) had occurred within 14 days of the procedure. For cases where it was not possible to confirm that dehiscence had occurred, but clinical records and outcome suggested it was possible, a third category of *possible* dehiscence was used.

For the purpose of data analysis, the following definitions were determined prior to data collection. A "low pre-operative serum albumin" was defined as any value lower than one standard deviation below the lower limit of the reference interval. An overall diagnosis of neoplasia was assigned to an individual case if the histopathology report concluded a diagnosis of neoplasia from one or more of the gastrointestinal biopsy sites. Additional abdominal surgical procedures performed under the same general anaesthesia as the gastrointestinal biopsy were classified as minor (biopsy of an intra-abdominal organ, e.g. liver, pancreas, mesenteric lymph node or placement of an oesophageal feeding tube) or major (all other abdominal surgery, e.g. enterectomy, cholecystectomy, liver lobectomy, gastrostomy tube placement). A case was deemed to have *definite* post-operative gastrointestinal dehiscence and associated septic peritonitis by one or more of the following methods: identification of intracellular bacteria on cytological assessment of peritoneal fluid, positive bacterial culture from peritoneal fluid, consistent gross findings at revision surgery and/or post-mortem examination confirmation. A case was deemed to have *possible* post-operative gastrointestinal

dehiscence and associated septic peritonitis if this was suspected based on review of the submitted clinical information but was neither confirmed nor excluded by any of the methods listed above. The term *suspected* dehiscence included all cases of *definite* and *possible* dehiscence.

Initial analysis related the various explanatory variables to the outcome of "*definite* dehiscence" and "dead within 14 days". Secondary analysis related these variables to the outcome "*suspected* (*definite* and *possible*) dehiscence".

## Statistical analysis

The statistical analysis was preplanned to examine the relationship between the outcome measures and four risk factors (low preoperative serum albumin, concomitant neoplasia, an additional major abdominal surgical procedure and colonic biopsy) using multivariable logistic regression. According to conventional calculations (Vittinghoff & McCulloch 2007), this would require, at the very least, 40 complications (outcome measures) and, assuming a similar incidence of dehiscence as previous studies (see above), imply the need to collect about 400 cases.

In this study, we found a lower rate of dehiscence than predicted, and so, exploratory analysis was carried out using univariable logistic regression with odds ratios and 95% confidence intervals calculated for various putative risk factors.

## RESULTS

### Cats

A total of 172 cats from 12 submitting institutions met the inclusion criteria. Age at the time of gastrointestinal biopsy was available for 166 cats; median age was 105.8 months (range 6.4 to 240.7 months). There were 3 entire male cats, 3 entire female cats, 104 neutered male cats and 62 neutered female cats. There were 103 domestic shorthair cats, 10 domestic longhair cats, 9 Siamese cats, 8 Persian cats, 7 Bengal cats, 7 Burmese cats, 6 ragdoll cats, 6 Maine coon cats, 4 British shorthair cats, 4 Oriental cats, 3 Birman cats and 1 each of a number of other breeds (Balinese, Egyptian mau, exotic shorthair, Havana brown and unknown).

The number of gastrointestinal biopsies performed is shown in Table 1a. A preoperative serum albumin concentration was available for 163 cats and was low in 17 (10.4%). Histopathological analysis was available for 170 cats; neoplasia was diagnosed at one or more sites in 30 (17.6%). Information regarding concurrent abdominal surgical procedures was available for 164 cats; of these, 42 (25.6%) had another major abdominal procedure performed at the same time as gastrointestinal biopsy.

Of the 172 cats in the study, 2 (1.2%) had *definite* dehiscence of a gastrointestinal biopsy site, corresponding to odds of 0.012 (95%CI: 0.003 to 0.047). Dehiscence was excluded definitively in 166 cats (96.5%). The remaining four cats had insufficient information in the clinical record to definitively rule out dehiscence and were therefore classed as having *possible* dehiscence; three deteriorated in the post-operative period and were euthanased as

a result, and one died suddenly three days post-operatively. Investigation into the cause of the post-operative deterioration in these cases was either not performed or not reported, and therefore, the possibility of dehiscence could not be definitively excluded. Six cats (3.5%) were classified as having *suspected* dehiscence.

For the two cats with *definite* dehiscence, both had a low preoperative serum albumin concentration, and neither had an additional major surgical procedure performed under the same general anaesthesia. One cat was diagnosed with *definite* dehiscence of multiple gastrointestinal biopsy sites at post-mortem examination seven days post-operatively; the cause of the dehiscence was recorded as unknown. This cat had a single biopsy taken from the stomach, jejunum and colon and did not have a diagnosis of neoplasia. The second cat with *definite* dehiscence was diagnosed with septic peritonitis two days after a single jejunal biopsy based on cytological/bacteriological testing. Information relating to the reason for dehiscence was not available for this cat, and a histopathological diagnosis of intestinal lymphoma was obtained from the biopsy. Both of the cats with *definite* dehiscence were dead at 14 days post-operatively.

A total of 154 cats (89.5%) were alive at 14 days post-operatively. Of the 18 cats that were not alive, 14 were euthanased (77.8%), and 4 died (Table 1b). Eight cats were euthanased because of a perceived poor prognosis associated with the histopathology result and the remaining six cats because of poor post-operative recovery. Details relating to the postoperative recovery and timing of euthanasia were infrequently reported.

The planned statistical analysis was inappropriate because of infrequent dehiscence. Only two *definite* dehiscence events were reported, and both of these were in cats with low preoperative serum albumin concentrations, meaning that logistic regression or calculation of odds ratios on this end point were not feasible (Table 1c). An exploratory Fisher's exact test suggests that low albumin was significantly associated with dehiscence ( $P=0.01$ ).

The incidence of *suspected* dehiscence, 6/172, was also low (3.5%) but allowed more statistical exploration. Four of the six cats had low albumin, so the odds ratio for *suspected* dehiscence in cats with low albumin was 22.2 (95% CI: 3.7 to 132.7); the wide confidence interval resulting from the small number of "events" recorded and consequent poor precision. There seemed to be low risk of *suspected* dehiscence associated with any of the other pre-specified variables (Table 1d), although the power of all these analyses was extremely low.

The final outcome that was explored was death within the first 14 days post-operatively (Table 1e). A total of 18 cats were dead within two weeks of surgery as a result of having died ( $n=4$ ), euthanasia due to poor post-operative recovery ( $n=6$ ) or euthanasia based on the prognosis following histopathology ( $n=8$ ). There was some evidence to suggest that a low preoperative serum albumin concentration was associated with death. Seven of 17 cats with a low albumin concentration, compared to 10 of 146 cats with a normal albumin concentration, were dead within 14 days; an odds ratio of 9.52 (95% CI: 2.98 to 30.36). A histopathological diagnosis of neoplasia was also associated with death within the first 14 days post-operatively in univariable analysis; odds ratio of 4.73 (95% CI: 1.68 to 13.29). Despite the larger number

of events (deaths) in these analyses, the precision in calculation of odds ratios is low.

## Dogs

A total of 195 dogs from 12 submitting institutions met the inclusion criteria. Age at the time of gastrointestinal biopsy was available for 193 dogs; median age was 77.1 months (range 0.2 to 180.5 months). There were 42 entire male dogs, 19 entire female dogs, 64 neutered male dogs and 70 neutered female dogs. There were 25 Labrador retrievers, 20 cross-breeds, 12 German shepherd, 10 boxers, 10 English springer spaniels, 9 cocker spaniels, 7 Border collies, 7 Jack Russell terriers, 6 cavalier King Charles spaniels, 6 dachshunds, 6 rottweilers, 6 Staffordshire bull terriers, 5 golden retrievers, 5 Weimaraners, 5 West Highland white terriers, 4 miniature schnauzers, 3 Dalmatians, 3 Irish setters, 3 Lhasa apso, 2 Border terriers, 2 bull mastiffs, 2 Dobermanns, 2 French bulldogs, 2 great Danes, 2 lurchers, 2 shih-tzus, 2 whippets and 1 each of a number of other breeds (Basset bleu de gascogne, Bedlington terrier, Bernese mountain dog, bichon frise, bloodhound, bouvier des Flandres, chow chow, English bulldog, English bull terrier, flat-coated retriever, fox terrier, German shorthaired pointer, greyhound, Hungarian vizsla, keeshond, leonberger, Maltese terrier, Newfoundland, Norwich terrier, old English sheepdog, Scottish terrier, shar pei, Shetland sheepdog, Siberian husky, Skye terrier, standard poodle and St. Bernard).

The number of gastrointestinal biopsies performed is shown in Table 2a. A preoperative serum albumin concentration was available for 171 dogs and was low in 53 (31.0%). Histopathological analysis was available for all 195 dogs; neoplasia was diagnosed at one or more sites in 24 (12.3%). Information regarding concurrent surgical procedures was available for 168 dogs; of these, 81 (48.2%) had another major abdominal surgical procedure performed at the same time as gastrointestinal biopsy.

Of the 195 dogs in the study, 2 (1.0%) had *definite* dehiscence of a gastrointestinal biopsy site, corresponding to odds of 0.010 (95% CI: 0.003 to 0.042). Dehiscence was excluded definitively in 190 dogs (97.4%). The remaining three dogs had insufficient information in the clinical record to definitively rule out dehiscence and were therefore classed as having *possible* dehiscence; two died three days post-operatively, and one suffered cardiopulmonary arrest in the post-operative period (timing not reported) and was successfully resuscitated. Investigation into the cause of the post-operative deterioration in these cases was either not performed or not reported, and therefore, the possibility of dehiscence could not be definitively excluded. Five dogs (2.6%) were classified as having *suspected* dehiscence.

Neither of the two dogs with *definite* dehiscence had a low preoperative serum albumin concentration, colonic biopsy, final diagnosis of neoplasia or additional major abdominal surgical procedure performed under the same general anaesthesia. One dog was diagnosed with *definite* dehiscence of the jejunal biopsy site at repeat surgery one day post-operatively. This dog had a single biopsy taken from the duodenum, jejunum and ileum. Iatrogenic damage to the mesenteric border at the jejunal biopsy site was reported at the first surgery, which was repaired. It was this repair of the mesenteric border that dehiscenced rather than the

**Table 1. Data relating to gastrointestinal biopsy, outcome (dehiscence and death) and putative risk factors in cats**

<b>(a) Frequency table of number of gastrointestinal biopsies performed</b>											
<b>Biopsy site</b>	<b>Stomach</b>		<b>Duodenum</b>		<b>Jejunum</b>		<b>Ileum</b>		<b>Caecum</b>	<b>Colon</b>	
Number of biopsies taken	1	2	1	2	1	2	3	1	2	1	1
Number of cats	100	2	120	5	127	10	1	96	1	11	13
Total number of cats	102		125		138			97		11	13
<b>(b) Summary of cats dead at 14 days post-operatively</b>											
<b>Cat</b>	<b>Died (D), Euthanased (E) or Euthanased on basis of histopathology result (E (HP))</b>		<b>Reason</b>								
1	D		Died 12 hours post-operatively. Post-mortem examination revealed a small volume of blood in the abdomen.								
2	D		Preoperative hypotension persisted in to post-operative period and was poorly responsive to medical management.								
3	D		Died three days post-operatively. No further information given.								
4	D		Died seven days post-operatively. Post-mortem examination revealed dehiscence of multiple biopsy sites – cause for leakage recorded as unknown.								
5	E		Euthanasia performed due to poor post-operative recovery. Post-mortem examination excluded dehiscence.								
6	E (HP)		Jejunal carcinoma with metastasis to mesenteric lymph node. Euthanasia performed on basis of poor prognosis.								
7	E		Developed perforated duodenal ulcer in post-operative period. Managed surgically but poor recovery and owner requested euthanasia. A duodenal biopsy was not performed in this case.								
8	E (HP)		Jejunal lymphoma with hepatic involvement. Euthanasia performed on basis of poor prognosis.								
9	E (HP)		Diagnosed with Feline infectious peritonitis based on histopathology result. Euthanasia performed on basis of poor prognosis.								
10	E		Euthanasia performed due to poor post-operative recovery.								
11	E		Euthanasia performed due to poor post-operative recovery.								
12	E (HP)		Colonic carcinoma with metastasis to liver and omentum. Poor post-operative recovery. Euthanasia performed on basis of poor prognosis.								
13	E (HP)		Small intestinal adenocarcinoma. Poor post-operative recovery. Euthanasia performed on basis of poor prognosis.								
14	E (HP)		Diagnosed with Feline infectious peritonitis based on histopathology result. Poor post-operative recovery. Euthanasia performed on basis of poor prognosis.								
15	E (HP)		Small intestinal lymphoma. Euthanasia performed on basis of poor prognosis.								
16	E		Euthanasia performed due to poor post-operative recovery.								
17	E (HP)		Unable to differentiate between lymphoplasmacytic enteritis and lymphoma histopathologically. Poor post-operative recovery. Euthanasia performed on basis of poor prognosis.								
18	E		Euthanasia performed due to poor post-operative recovery.								
<b>(c) Comparison of cats with suspected dehiscence (definite and possible) and four putative risk factors.</b>											
<b>Case number</b>	<b>Dehiscence (definite versus possible)</b>		<b>Low preop serum albumin (Y/N)</b>	<b>Biopsy through neoplastic tissue (Y/N)</b>	<b>Biopsy alongside another major surgical procedure (Y/N)</b>	<b>Biopsy of the colon (Y/N)</b>					
1	Definite		Y	Y	N	N					
2	Definite		Y	N	N	Y					
3	Possible		Y	Y	N	N					
4	Possible		N	N	Y	N					
5	Possible		Y	N	N	N					
6	Possible		N	N	Y	N					
<b>(d) Univariable logistic regression analysis of relationship between suspected dehiscence (definite and possible) and four putative risk factors</b>											
	<b>Odds ratio</b>		<b>95% CI</b>		<b>P value</b>						
Low albumin	22.15		3.70 to 132.66		0.001						
Neoplasia	2.43		0.42 to 13.91		0.319						
Other surgery	1.58		0.28 to 8.92		0.608						
Colonic biopsy	2.57		0.28 to 23.77		0.407						
<b>(e) Univariable logistic regression analysis of relationship between death by 14 days post-operatively and four putative risk factors</b>											
	<b>Odds ratio</b>		<b>95% CI</b>		<b>P value</b>						
Low albumin	9.52		2.98 to 30.36		<0.0001						
Neoplasia	4.73		1.68 to 13.29		0.003						
Other surgery	0.87		0.27 to 2.81		0.819						
Colonic biopsy	1.63		0.33 to 7.99		0.550						

**Table 2. Data relating to gastrointestinal biopsy, outcome (dehiscence and death) and putative risk factors in dogs**

<b>(a) Frequency table of number of gastrointestinal biopsies performed</b>															
<b>Biopsy site</b>	<b>Stomach</b>		<b>Duodenum</b>			<b>Jejunum</b>				<b>Ileum</b>		<b>Caecum</b>	<b>Colon</b>		
Number of biopsies taken	1	2	1	2	3	1	2	3	4	1	2	1	1	2	3
Number of dogs	112	17	143	6	1	124	9	2	1	88	1	2	4	1	1
Total number of dogs	129		150			136				89		2			6

  

<b>(b) Summary of dogs dead at 14 days post-operatively</b>		
<b>Dog</b>	<b>Died (D) or Euthanased (E)</b>	<b>Reason</b>
1	D	Free fluid in abdomen three days post-operatively. No further information given.
2	D	Died 12 hours post-operatively. No further information given. Post-mortem examination declined.
3	D	Died three days post-operatively. No further information given.
4	D	Died seven hours post-operatively. No further information given.
5	D	Died 11 days post-operatively. No further information given.
6	D	Died six days post-operatively. No further information given.
7	E	Euthanasia performed due to poor post-operative recovery.
8	E	Euthanasia performed due to poor post-operative recovery.
9	E	Euthanasia performed due to poor post-operative recovery (after 3 <sup>rd</sup> surgery).
10	E	Euthanasia performed due to poor post-operative recovery.
11	E	Euthanasia performed due to poor post-operative recovery (documented ascending infection from peritoneal drain).

  

<b>(c) Comparison of dogs with suspected dehiscence (definite and possible) and four putative risk factors</b>					
<b>Case number</b>	<b>Dehiscence (definite versus possible)</b>	<b>Low preop serum albumin (Y/N)</b>	<b>Biopsy through neoplastic tissue (Y/N)</b>	<b>Biopsy alongside another major surgical procedure (Y/N)</b>	<b>Biopsy of the colon (Y/N)</b>
1	Definite	N	N	N	N
2	Definite	N	N	N	N
3	Possible	Y	N	N	N
4	Possible	N	N	Y	N
5	Possible	N	N	Y	N

anti-mesenteric biopsy site. This dog was euthanased due to a poor recovery from a third surgery to address a second episode of septic peritonitis. The second dog with *definite* dehiscence was diagnosed with septic peritonitis three days after a single biopsy was taken from each of the stomach, duodenum, jejunum and ileum based on cytological and/or bacteriological testing. Information relating to the site and reason for dehiscence, or management following the diagnosis of septic peritonitis, were not available for this dog although it was alive at 14 days post-operatively.

A total of 184 dogs (94.4%) were alive at 14 days post-operatively. Of the 11 dogs that were not alive, 5 were euthanased (45.5%), and 6 died (Table 2b). The reason for euthanasia in all five dogs was a poor post-operative recovery and not because of perceived poor prognosis associated with the histopathology result. Details of the post-operative recovery and the timing of euthanasia were infrequently reported.

The planned statistical analysis was inappropriate because neither of the *definite* dehiscence dogs had a low preoperative serum albumin concentration, colonic biopsy, diagnosis of neoplasia or an additional major abdominal surgical procedure performed (Table 2c). The incidence of *suspected* dehiscence, 5/195, was also low (2.6%), and there was no association between this and any of the putative risk factors investigated.

The final outcome that was explored was death within the first 14 days post-operatively, and again, there was no apparent association of this outcome with any of the four investigated variables.

## DISCUSSION

This study reports a low incidence of *definite* dehiscence following full-thickness gastrointestinal biopsy in dogs (1%) and cats (1.2%). These findings are comparable to the 0% incidence of dehiscence following full-thickness gastrointestinal surgery previously reported in cats (Ralphs *et al.* 2003, Smith *et al.* 2011) and are notably lower than has previously been reported for dogs (Shales *et al.* 2005). The incidence of *suspected* dehiscence (2.6% in dogs and 3.5% in cats) takes into account the cases in which dehiscence could not be definitively excluded based on the submitted data and may include cases that did not dehisce, leading to a possible over-estimation.

It is paramount that the potential benefits of an invasive procedure, such as surgical gastrointestinal biopsy, with possibly life-threatening associated complications are scrutinised closely when a less invasive technique is available. If analysis of endoscopic gastrointestinal biopsy samples were to consistently provide an

accurate diagnosis, then it would not be possible to justify a surgical technique to obtain the same information.

However, the histopathological distinction between an inflammatory enteropathy and neoplasia can be challenging. For example, attempting to differentiate between chronic inflammation (e.g. inflammatory bowel disease) and small cell lymphoma in cats is notoriously difficult (Willard *et al.* 2009). A key histological feature used to differentiate feline intestinal lymphoma from inflammatory bowel disease is lymphoid infiltration beyond the mucosa in lymphoma (Kiupel *et al.* 2011). The need to obtain a biopsy sample that includes intestinal wall deep to the mucosa implies the need to collect a full-thickness surgical biopsy. On the other hand, techniques such as immunophenotyping and PCR to determine clonality of infiltrating lymphocytes may allow accurate differentiation between intestinal lymphoma and inflammation on endoscopic mucosal biopsy samples in dogs and cats (Kiupel *et al.* 2011, Carrasco *et al.* 2015). Even so, although biopsies of the gastric and duodenal mucosa are readily obtained endoscopically, access to the ileum requires lower gastrointestinal endoscopy, with the need for appropriate colonic preparation pre-sampling, and the jejunum is not accessible via this approach. Poor agreement between endoscopic biopsies from the duodenum and ileum has been shown when attempting to distinguish feline inflammatory bowel disease and alimentary lymphoma, and a diagnosis of lymphoma could only be found by evaluation of ileal biopsies in a subset of cats (Scott *et al.* 2011). Similar discrepancies in histopathological diagnosis were also apparent when duodenal and ileal biopsies from dogs with enteropathy were compared (Casamian-Sorrosal *et al.* 2009). These studies highlight the importance of obtaining a biopsy from the ileum in order to maximise the likelihood of obtaining an accurate diagnosis and therefore support the use of a surgical biopsy technique if the required expertise is not available to obtain an endoscopic ileal biopsy.

One study comparing endoscopic and surgical biopsy for the diagnosis of inflammatory bowel disease and alimentary lymphoma in cats concluded that endoscopic biopsy provided a diagnosis of lymphoma in only 3 of 10 cats confirmed to have lymphoma by surgical biopsy (Evans *et al.* 2006). Endoscopic biopsies were not obtained from the ileum, although surgical biopsies were; therefore, this study does not directly compare the biopsy techniques, and the absence of endoscopic ileal biopsies is likely to account for the low detection of lymphoma with this technique.

A further advantage of surgical biopsy via a midline coeliotomy is the opportunity to perform a thorough abdominal exploration and to sample any grossly abnormal tissue that may be identified, which can, for instance, be advantageous in investigations of chronic gastrointestinal disease in cats (Klienschmidt *et al.* 2010). Surgical biopsies can also be obtained without the need for specialist equipment, meaning they are readily performed in general practice and consequently provide a means of reaching a diagnosis in cases that are not candidates for referral. It is worth noting that patients undergoing coeliotomy for another surgical technique (e.g. cholecystectomy, liver lobectomy) may have concurrent surgical gastrointestinal biopsy performed as it

makes sense to obtain surgical biopsies rather than perform an additional endoscopic procedure. Any concerns regarding the post-operative recovery following coeliotomy may be obviated by performing laparoscopically assisted intestinal biopsy, although the intestinal dehiscence rate with such a technique is likely comparable to that when biopsies are obtained via coeliotomy as the intestinal surgical biopsy technique is identical for the two procedures (Mitterman *et al.* 2016).

Both *definite* and *suspected* dehiscence were associated with a low preoperative serum albumin concentration in cats, although caution is required in interpreting this finding because of the low number of dehiscence events and consequent low study power. This finding is in contrast to some previous publications investigating the potential association between preoperative serum albumin and incidence of gastrointestinal dehiscence in dogs and cats (Harvey 1990, Wylie & Hosgood 1994, Smith *et al.* 2011). A possible reason for this discrepancy is the larger number of cases included in our study, permitting us to identify associations of lower magnitude of effect despite the low number of dehiscence events overall. The necessary role of proteins in wound healing is widely accepted, but the exact contribution of, and necessity for, albumin is unknown. Low serum albumin may not necessarily be causative for impaired tissue healing but, instead, associated with it. For example, cats and dogs that are systemically unwell may present with a reduced serum albumin concentration and have impaired tissue healing for other reasons such as poor tissue perfusion. None of the other proposed risk factors were associated with dehiscence in cats. With a low incidence of *definite* and *suspected* dehiscence, the power of the study was low, meaning weak associations may not have been detected even if they did exist. On the other hand, unless an association is reasonably strong and can be detected in a data set of this size, it may suggest that it is not likely to be of great clinical importance.

Cats with a low preoperative albumin concentration were more likely to be dead at 14 days post-operatively than those with a normal albumin concentration. Those with a histopathological diagnosis of neoplasia were also more likely to be dead at 14 days post-operatively. The latter association is likely to be causative as a poor prognosis associated with the histopathological diagnosis was cited as the reason for euthanasia in 57.1% (8/14) of euthanased cats. This finding suggests that gastrointestinal biopsy may still be worthwhile even if treatment is not pursued because obtaining a histopathological diagnosis may serve to guide owners' decisions regarding management options.

Neither *definite* nor *suspected* dehiscence was significantly associated with any of the risk factors investigated in dogs. Again, with a low incidence of *definite* dehiscence, the power of the study was low. Similarly, none of the proposed risk factors were associated with death by 14 days post-operatively in dogs. Interestingly, a poor prognosis associated with the histopathological diagnosis was not cited as the reason for euthanasia in any of the five dogs that were euthanased, which is in contrast to the cats in the study. All dogs that were euthanased had a non-neoplastic histopathological diagnosis (enteritis or no abnormality detected) and were euthanased due to poor postoperative recovery. The data table submitted to the contributing institutions

was designed to obtain information from the clinical records that enabled us to determine the principle outcome variables: if the case was dead or alive at 14 days post-operatively and if the case had a dehiscence event (yes/no/possibly). Obtaining a detailed account of case management and clinical progress in the postoperative period was beyond the scope of the table submitted and the aims of the study. The absence of this information does limit further interpretation of the cases that died or were euthanased for reasons other than a poor prognosis associated with the histopathological diagnosis.

The 1% incidence of *definite* dehiscence following full-thickness gastrointestinal biopsy in dogs is substantially lower than the 12% previously reported (Shales *et al.* 2005). It is difficult to offer an explanation for this as both studies included cases operated solely by referral institutions, and there were only two years between cessation of data collection for the study by Shales *et al.* (2005) and the initiation of data collection for the current study; hence, a temporal effect is considered unlikely. It is possible that the cases included in the study by Shales *et al.* (2005) were either systemically unwell to a greater degree or had comorbidities, which caused them to be a greater anaesthetic and/or surgical risk. It is challenging to objectively document the preoperative stability of a patient and then accurately recall this information; therefore, directly comparing the two studies in this respect is not possible. None of the cases included in the study by Shales *et al.* (2005) were reported to have preoperative septic peritonitis, which was an exclusion criteria for the current study, thereby eliminating the possibility of inclusion of this subgroup of critical patients in the study reporting a 12% incidence of dehiscence. In the present study, 25% of cats and 48% of dogs had another major abdominal surgical procedure performed at the same time as the gastrointestinal biopsies compared to 9% of the dogs reported by Shales *et al.* (2005). This difference suggests that the principal reason for surgery in the earlier paper was to obtain gastrointestinal biopsies for investigation of a chronic enteropathy, whereas the concurrent major abdominal surgical procedure performed in a high percentage of the cases presented here was likely the primary indication for surgery, and as such, these patients may have been more likely to present with systemic illness and possibly posed a greater anaesthetic or surgical risk. This theory supports an expectation that cases undergoing a concurrent major abdominal surgical procedure may be less stable and therefore at increased risk of post-operative complications (e.g. dehiscence), which does not explain the different incidence of dehiscence reported by the two studies.

A major limitation of this study is the retrospective nature of the data collection. Incomplete data submission meant it was not always possible to definitively determine if dehiscence had occurred or not. As previously stated, this led to an incidence of *suspected* dehiscence that might be an over-estimation of the actual incidence. On the other hand, retrospective data collection of this nature might also lead collaborators to omit cases that might be considered to “show them in a bad light”, and so, there may be a suspicion of bias towards more optimistic outcomes, although anonymisation of data should help to minimise this effect. Also, our inclusion criteria will have inevitably led to

the exclusion of some cases because of incomplete clinical records or inadequate length of follow-up. For instance, it could be that some cases that were not included were those that dehisced and were subsequently managed by the referring practice without feedback to the referral centre where the initial biopsy procedure was performed and from where our data was derived. Such a series of events could lead to the reporting of an erroneously low incidence of dehiscence.

Another factor that may have lead to under-estimation of the incidence of dehiscence is the potential impact of the 12 cats and 8 dogs that died or were euthanased within the first 14 days post-operatively but were not categorised as either *definite* or *possible* dehiscence. This subset of non-survivors either deteriorated post-operatively and subsequently died or were euthanased (cats n=5, dogs n=8), or they were euthanased on the basis of a poor prognosis associated with the histopathological diagnosis (cats n=7, dogs n=0). The early post-operative death or euthanasia of these cases means that they may not have survived for a sufficient period post-operatively for dehiscence to occur and be detected. Having said this, those cases euthanased on the basis of a histopathology result are likely to have been managed for several days post-operatively whilst the tissue was analysed and, therefore, were likely alive during the high risk *lag phase* of intestinal healing. Unfortunately, the exact timing of death or euthanasia in relation to the surgery date was rarely available, and consequently, more specific analysis was not possible.

There was also a degree of assumption that a diagnosis of septic peritonitis equated to dehiscence of the gastrointestinal biopsy site, the latter only being definitively confirmed if either repeat surgery or post-mortem examination was performed, and this was the case in only two of four animals assigned to the *definite* dehiscence category. Although unlikely, other causes of septic peritonitis, such as ascending infection from a peritoneal drain, intraoperative contamination or spontaneous bacterial peritonitis, could not be eliminated as the cause of the peritonitis in the remaining two *definite* dehiscence cases.

This study reports the incidence of surgical site dehiscence after full-thickness gastrointestinal biopsy performed at referral hospitals in the UK. These results may not reflect the incidence of dehiscence after the same procedure is performed in general practice, and it would be of interest to establish the incidence at non-referral UK hospitals over the same time period. It is assumed that the incidence of intestinal dehiscence reported in this study relates to surgical cases where an appropriate suture material and suture technique was used to close the intestinal biopsy site. Analysis of the suture material and suture technique used for the cases included was beyond the scope of this retrospective study, and it is important to recognise that the dehiscence rate is likely to be considerably higher than that reported if the intestinal biopsy site is not closed appropriately.

In conclusion, performing full-thickness gastrointestinal biopsy in dogs and cats can be considered a low-risk procedure at referral hospitals in the UK, although a definite dehiscence rate of 1% is not negligible given the high mortality rate associated with dehiscence. Consequently, case selection should be carefully considered based on the potential merits of the procedure on an

individual basis, and the client should be adequately informed preoperatively of the potential for life-threatening complications associated with surgical gastrointestinal biopsy.

Although this study cannot provide absolute proof of an association, it would be prudent to consider that, in cats, a low preoperative serum albumin concentration might be associated with an increased risk of dehiscence or death by 14 days, and this risk should be factored into the decision-making process. Future prospective investigation into the potential association between low preoperative serum albumin and intestinal dehiscence risk should be considered.

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### Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper. The second named author (NJ) is Editor-in-Chief of this journal. He took no part in reviewing, selecting reviewers nor decision-making for acceptance of this manuscript; these roles were taken by Dr Gerry Polton.

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