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Research article

Prevalence of an empty colon in patients with acute and chronic small intestinal mechanical obstruction: A retrospective radiographic study in 100 dogs and cats

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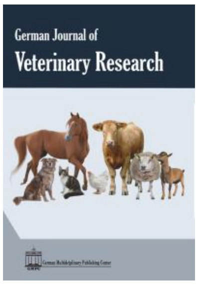

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Abstract

Small intestinal mechanical obstruction (SIMO) is a common clinical condition, with radiographic studies typically focusing on the small intestine. However, the colon's appearance in SIMO has not been extensively studied. This retrospective study aimed to determine the prevalence of an empty colon on radiographs of dogs and cats with confirmed SIMO. Pre-surgical abdominal radiographs of 100 patients (68 dogs and 32 cats) with surgically confirmed mechanical ileus and a control group of 30 dogs and 20 cats with non-obstructive gastrointestinal (GI) disease and one without GI disease, respectively, were evaluated. The colon was assessed for content (none/collapsed, gas, faeces) and segmental distribution (ascending, transverse, descending colon) and correlated to the duration of clinical signs (acute, chronic). A colon was classified as empty when ≥2/3 was collapsed and/or gas-filled. The overall prevalence of an empty colon in cases of mechanical ileus was 61% (p=0.028), with 49/68 in dogs (72.1%) and 12/32 in cats (37.5%), p=0.001 between dogs and cats. Clinical signs duration did not influence the prevalence 28/61 (45.9%) acute, 33/61 (54.1%) chronic, p=0.522. However, acute cases had more empty colon segments (2/3 segments: 6/28, 21.4%; 3/3 segments: 22/28, 78.6%) than chronic cases (2/3 segments: 23/33, 69.7%; 3/3 segments: 10/33, 30.3%; p≤0.001). In the control groups, the prevalence of an empty colon was 64% (p=0.048) with and 38%, p=0.048) without GI disease, with no statistical difference between dogs and cats. An empty colon can be a supporting radiographic finding in diagnosing patients with GI disease, including SIMO, in addition to other established characteristic features. Dogs are more likely to have an empty colon in the presence of mechanical ileus.

Keywords: Colon, Empty, Gastrointestinal disease, Radiography, Small intestinal mechanical obstruction

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Introduction

Small intestinal mechanical obstruction (SIMO) is common in veterinary practice, particularly in vomiting patients (Palminteri, 1972; Lamb and Hansson, 1994; MacPhail, 2002; Hayes, 2009; Drost et al., 2016; Elser et al., 2020). It can be caused by various factors, such as ingesting foreign material, intussusceptions, neoplasia, or an extrinsic cause (Palminteri, 1972; Thrall, 2018). Abdominal survey radiographs are a fast, cost-effective diagnostic tool for accurately identifying SIMO and are commonly used as the first diagnostic modality (Kleine and Lamb, 1989; Zatloukal et al., 2004; Sharma et al., 2011; Elser et al., 2020).

A common radiographic sign of obstruction in the absence of a visible foreign body is a segmental fluid or gas-filled distention of the small intestine proximal to the obstruction site (Palminteri, 1972; Gibbs and Pearson, 1973; Lamb and Hansson, 1994; Finck et al., 2014; Thrall, 2018; Tobias and Johnston, 2018). Other signs include gastric dilatation by gas and/or fluid, abnormally shaped intestinal loops (e.g., stacked, hair-pin curvature), and the "gravel sign" (Adams et al., 2010; Ciasca et al., 2013). Quantitative thresholds have been established to assist clinicians in diagnosing SIMO, such as the ratio between the maximal small intestinal diameter and the height of the mid-vertebral body of the fifth lumbar vertebra in dogs (Graham et al., 1998; Finck et al., 2014), as well as the ratio of small intestine diameter and the height of the endplate of the second lumbar vertebra in cats (Thrall, 2018). However, it is important to exercise caution, as these thresholds do not necessarily enhance the accuracy of the diagnosis (Ciasca et al., 2013).

Limited information exists on how SIMO affects the colon and its related secondary radiographic findings (Adams et al., 2010). Complete and chronic partial obstructions can cause bowel dilation and concurrent colon emptiness (Lang et al., 2013). The small intestine distal to the obstruction is expected to be smaller in diameter and empty (Dennis et al., 2010; Agthe, 2011; Tobias and Johnston, 2018), and a similar effect on the colon can be expected. To the best of the author's knowledge, no studies have investigated the colon's radiographic appearance in the presence of SIMO. This study aimed to assess the presence of colon emptiness in a population of dogs and cats with surgically confirmed complete SIMO and compare it with a control group of dogs and cats with non-obstructive gastrointestinal disease and one control group without gastrointestinal disease.

We hypothesized that patients with SIMO were likelier to have an empty colon. Additionally, we expected to observe a higher prevalence of empty colons in cases of chronic SIMO than in acute presentations.

Material and methods

This retrospective, descriptive, cross-sectional study design did not require ethical approval from the Institutional Animal Care and Use Committee. The radiology department's supervisor granted permission to use hospital data for this research study. The Veterinary Hospital of Hofheim's patient database was searched for dogs and cats with surgically confirmed SIMO, non-obstructive gastrointestinal disease, and non-gastrointestinal abdominal disease between 2005 and 2024.

Search terms containing the terms intestinal obstruction, ileus, gastrotomy, enterectomy, and enterotomy were identified. Cases were deemed ineligible for the study if the obstruction was present in the colon, if the surgical report failed to identify and describe a complete SIMO, or if radiographs were taken more than 48 hours prior to surgery or after medical intervention (such as intravenous fluid therapy or analgesia). Inclusion criteria required that all cases had at least two orthogonal abdominal radiographs of good technical quality before surgery, encompassing the entire abdomen and colon. In certain cases, radiographs taken at the referring veterinary practice within 24 hours prior to admission to the Hofheim hospital were accepted, provided they met all eligibility criteria. One hundred cases fulfilled all the criteria selected for analysis.

A control group consisting of 100 patients was created, divided into two subgroups, each with 50 patients (30 dogs and 20 cats): one subgroup with gastrointestinal disease (excluding mechanical obstructions) and the other with abdominal, non-gastrointestinal disease. This enabled a comparison to identify potential differences or similarities in colon presentation between patients with diseases involving the gastrointestinal tract and those with abdominal but non-gastrointestinal diseases. The animals were randomly selected and identified (between 2005 and 2024) using the search terms inflammatory bowel disease (IBD), ileitis, diarrhea, enteritis, gastritis, gastroenteritis, pancreatitis, triaditis, typhlitis, and vomiting for the control group with gastrointestinal disease, and the terms adrenal disorders, ectopic ureter, nephropathy, prostatic disease, pyometra, splenic neoplasia, trauma, and urolithiasis for the control group with non-gastrointestinal abdominal disease. The same technical inclusion criteria were applied to all subjects.

The radiographs were reviewed independently by two experienced radiology residents (C.H.V., M.H.) using a dedicated medical imaging processing software (Osirix MD, v12.5.2, Pixmeo

SARL, Bernex, Switzerland; Horos, v3.3.6, GNU Lesser General Public License, version 3). All observers knew the study objective, had access to the full patient history at the review time, and recorded the same findings for each patient.

Patient data, including age, species, breed, sex, weight, year of presentation, duration of clinical signs (acute = under 24 hours, chronic = over 24 hours), clinical diagnosis, and type of surgical intervention, were collected using commercially available spreadsheet software (Microsoft Excel® 2019, Version 2308, Microsoft Corp, Redmond, WA).

The colon was defined as the intestinal segment between the ileocecal junction and the pelvic inlet. Each colon segment (ascending, transverse, descending colon) was assessed individually for its luminal content, and the empty segments were further classified as collapsed, gas-filled, or a combination of both (Figure 1). A colon segment was considered empty if at least 2/3 of the segment had no fecal content, and it was qualified as full if 1/3 or more contained fecal matter of any amount (Figure 2). Allowing a small amount of fecal matter to still qualify as empty allowed patients with minimal fecal matter not to be excluded and possibly distort results. A segment was considered to have a mixed pattern if both a collapsed lumen and a gas-filled lumen were present. If over two-thirds of a colon segment was filled predominantly by one pattern, it became the assigned pattern (collapsed, gas-filled, mixed). The colon was defined as empty when two or more segments were collapsed, filled with gas, or a combination of both. The degree of colon emptiness was graded as mild, moderate, or severe, depending on the number of empty segments (mild=1 empty segment, moderate=2 empty segments, severe=3 empty segments), and a predominant pattern was assigned (collapsed, gas-filled, mixed).

Discrepancies in radiographic interpretation between observers were discussed, and a consensus was reached, which was used for statistical analysis and interobserver agreement calculations. The radiographs of all cases with an empty ascending and transverse colon but a non-empty descending colon underwent a review conducted by a single observer (C. H. V.). During this re-evaluation, the amount of luminal fecal matter in the descending colon was reassessed and categorized into three groups depending on how many thirds of the descending colon were feces-filled (Figure 3 and Figure 4).

Statistical analyses

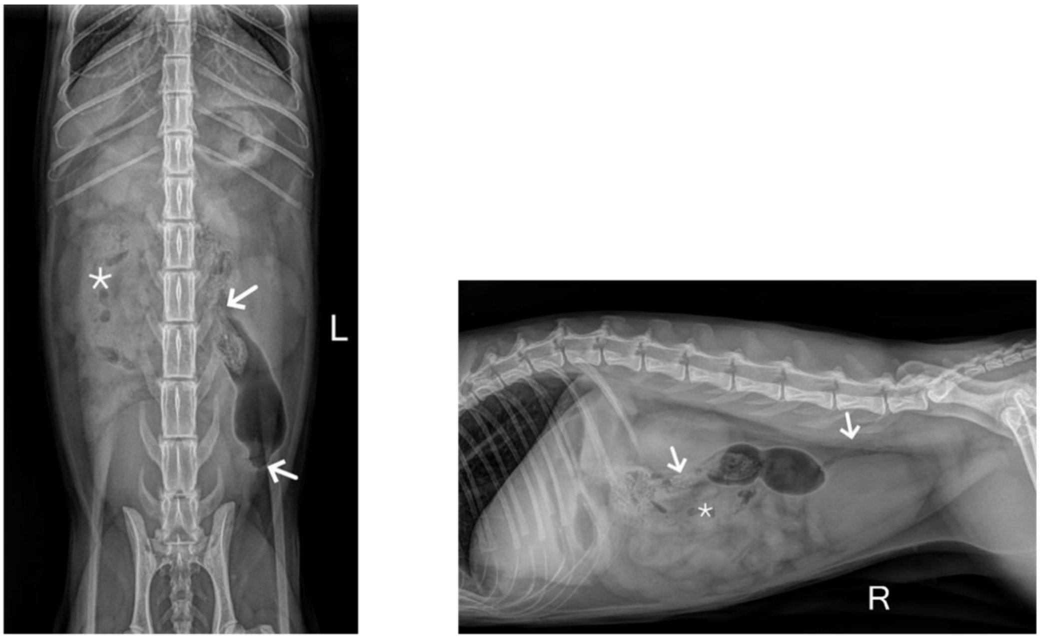
Statistical analyses were performed using statistical calculator software (IBM SPSS Statistics, Version 29.0.1.0) and commercially available software (Microsoft Excel® 2019 MSO, Version 2308, Build 16.0.16731.20182). The agreement between the two reviewers was assessed using Cohen's kappa coefficient, with interpretation categorized as poor (<0.00), slight (0.0-0.20), fair (0.21-0.40), moderate (0.41-0.60), substantial (0.61-0.80) and almost perfect (0.81-1.00) (Landis and Koch, 1977).

The prevalence of empty and non-empty colons in cases of acute and chronic SIMO, as well as in patients with and without gastrointestinal disease, was calculated for the total population and separately for the canine and feline cohorts for all groups. The statistical significance level was set at p-value < 0.05 to determine the significance of the hypothesis. To assess differences between empty and not-empty colons, as well as acute and chronic cases across the total study population of the groups, we used the chi-squared test of goodness of fit to calculate the p-values. Differences between the dog and cat cohorts were calculated using the chi-squared test of independence to compare the presence of an empty colon in acute and chronic cases. The prevalence and distribution of variables were manually calculated using spreadsheet software.

Results

SIMO group

Out of 100 SIMO patients included in the study, 68 were dogs, and 32 were cats. The age range of dogs was from one month to 14 years (median of four years), while cats ranged from three months to 11 years (median of two years). The majority of patients were under four years of age (58%). The three most common dog breeds were crossbreed dogs (10/68, 14.7%), Labrador retrievers (8/68, 11.7%), and golden retrievers (5/68, 7.35%). Among the cats, the three most common breeds were European shorthair (13/32, 40.6%), British shorthair (5/32, 15.6%), and crossbreed cats (4/32, 12.5%) (for all dog and cat breeds, see Table S1).



A B

Figure 1: (A) ventrodorsal and (B) right lateral abdominal radiograph of a three-year-old cat with acute mid jejunal intussusception showing moderate fecal matter in the ascending (*) and transverse colon. The lumen of the descending colon (arrows) contains 1/3 of faeces, gas, and collapsed areas, respectively. This colon was considered non-empty, as two segments contained fecal matter.

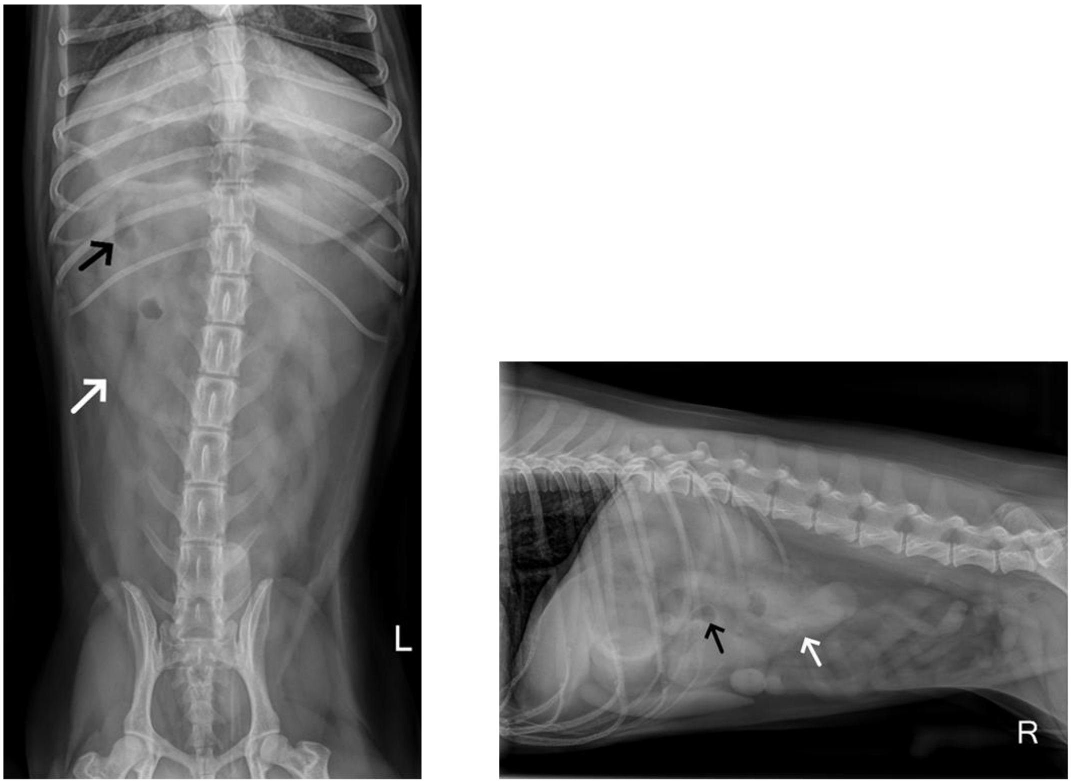


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Figure 2: (A) ventrodorsal and (B) right lateral abdominal radiograph of a five-year-old Jack Russel terrier with acute foreign body obstruction demonstrating a completely collapsed colon. Although the foreign material is not visible (plastic), small intestinal obstruction was suspected due to the distended and liquid-filled small intestinal loops in the cranial abdomen (white arrows) and small irregularly shaped intestinal gas inclusions (black arrows). The colon was considered empty as all segments were collapsed and contained no fecal matter.

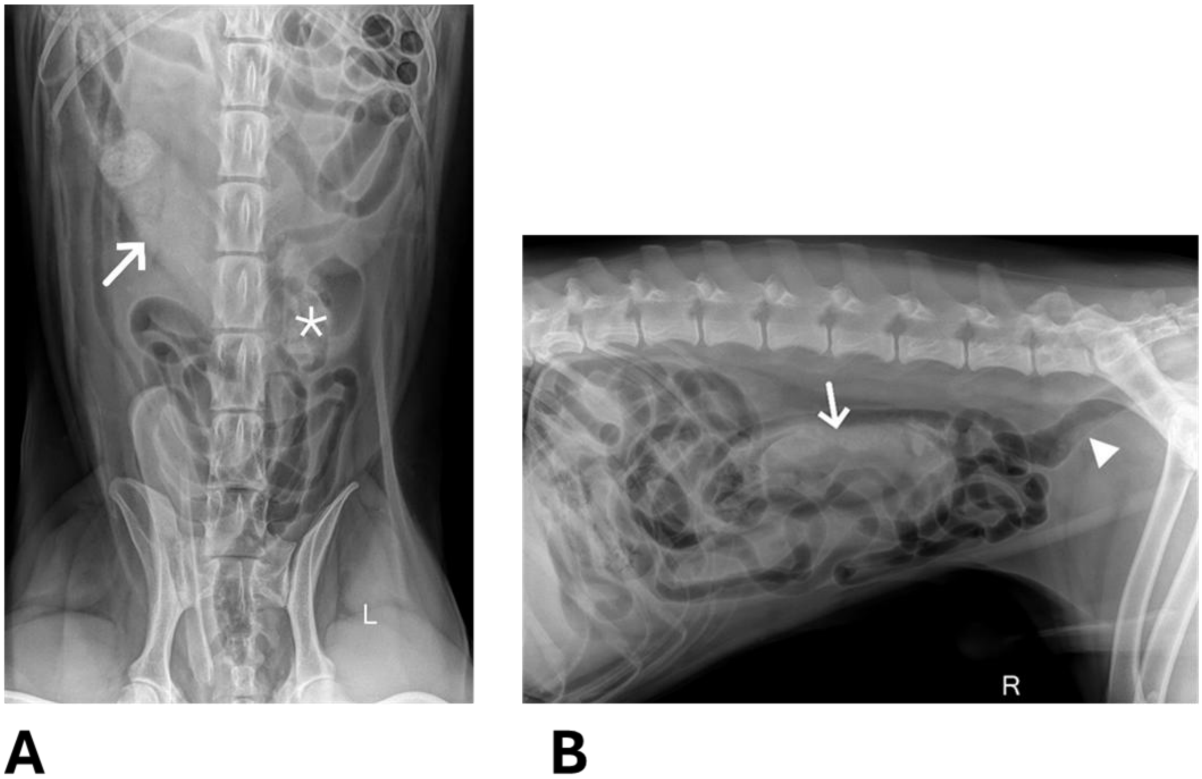

Figure 3: (A) ventrodorsal and (B) right lateral abdominal radiograph of a four-year-old Husky with intestinal obstruction proximal to the ileocolic junction by severely impacted mineralized material (white arrows) after ingestion of bones. The ascending and transverse colons are collapsed and not well-defined, there is a small amount of fecal matter (*) and gas (arrowhead) in the descending colon. This is classified as an empty colon, with one-third of the descending colon filled with feces.

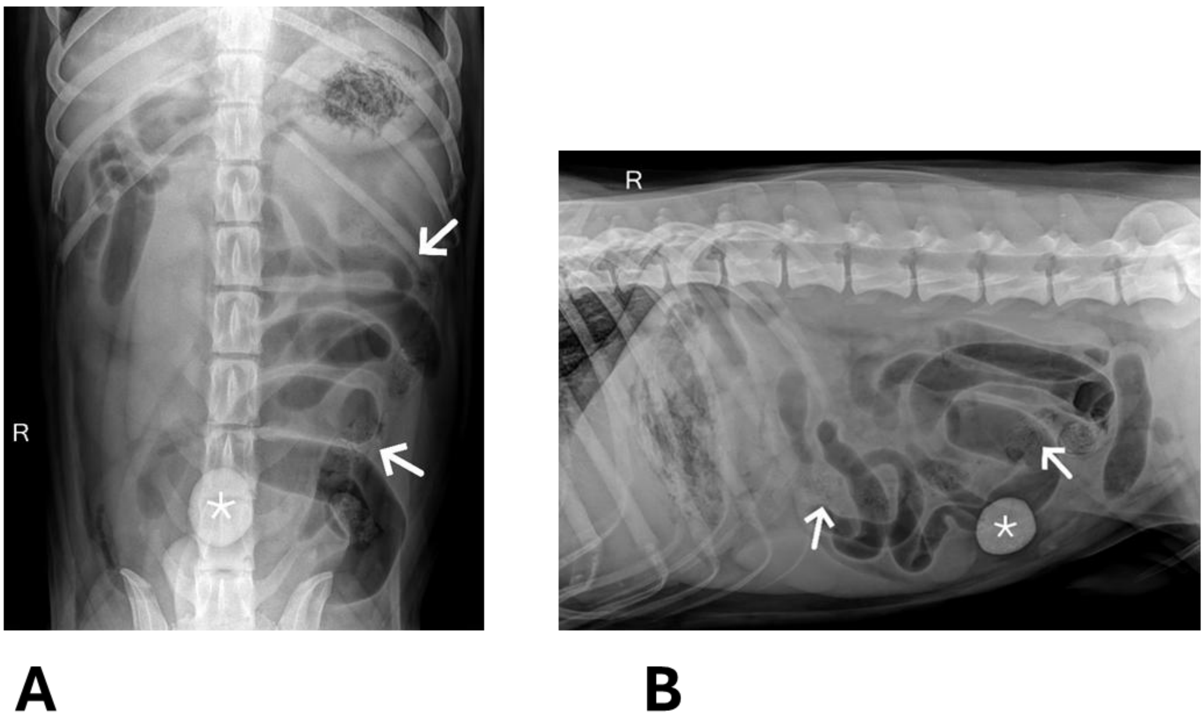

Figure 4: (A) ventrodorsal and (B) right lateral abdominal radiograph of an eight-year-old golden retriever with a jejunal obstruction by a stone (*). A segmental intestinal dilation with two populations can be observed. The stomach is filled with gas and soft tissue content. This colon was first classified as an empty colon, as the ascending and transverse colon segments are collapsed. It was reclassified as a full colon in the review, as over two-thirds of the descending colon (arrows) is filled with fecal matter.

Of the 68 dogs, 41 were male (59%) and 27 were female (42%). Out of the male dogs, 24 were entire, and 17 were neutered, and out of the female dogs, 15 were entire, and 12 were neutered. Among the 32 cats, 18 were male, with one entire and 17 neutered, and 14 were female, with two entire and 12 neutered. The weight distribution for dogs ranged from 2 kg to 48 kg (median 23 kg), while for cats, it ranged from 2 kg to 7 kg (median 4 kg). Among the patients, 95 out of 100 had a final diagnosis of small intestinal foreign body obstruction, while four had intussusceptions, and one had obstipation. Most cases required a single enterotomy (72/100), with 13 cases involving additional enterectomy or gastrotomy (13/72). Other surgical procedures included six enterectomies, one gastrotomy, one laparotomy with subsequent gastroscopic foreign body removal, and one with subsequent rectal removal of foreign material.

Regarding the colon status in the total population, 61 out of 100 patients had an empty colon, while 39 had a non-empty colon (p= 0.028), 43 had an acute presentation, and 57 had a chronic one (Table 1). Among the patients with an empty colon, 28 (45.90%) had an acute obstruction, and 33 (54.10%) had a chronic obstruction (p=0.522). When considering the degree of colon emptiness, acute cases had 10/38 (26.32%) with a mild degree, 6/38 (15.79%) with a moderate degree, and 22/38 (57.89%) with a severe degree of empty colon. Chronic cases had 9/42 (21.43%) with a mild degree, 23/42 (54.76%) with a moderate degree, and 10/42 (23.81%) with a severe degree of empty colon (p<0.001). As only one-third of the colon was empty in mild degrees, they did not qualify as an empty colon and, therefore, were not considered in the empty colon comparison calculations. Acute cases showed a higher incidence of an empty colon [moderate 6/28 (21.43%), severe 22/28 (78.57%)] compared to chronic cases [moderate 23/33 (69.7%), severe 10/33 (30.30%)] with a significant p-value of < 0.001. When analyzing the degree of emptiness for the dog and cat populations individually, there was no significant difference in the severity of emptiness between acute (p=0.932) or chronic (p=0.416) presentation.

There was a significant difference between the canine and feline populations (Table 2). A larger fraction of the dog cohort had an empty colon (49/68, 72.06%) than a full one (19/86, 27.94%). In contrast, among the cats, a higher proportion had a full colon (20/32, 62.50%) than an empty one (12/32, 37.50%, p<0.001). When considering acute and chronic presentations of the animals with an empty colon, there was no significant difference in either population: dogs (acute: 23/49, 46.94%; chronic 26/49, 53.06%), cats (acute: 5/12, 41.67%; chronic: 7/12, 58.33%) (p=0.743).

Out of the 24 reviewed empty colon cases with an empty ascending and transverse colon and a full descending colon, 11 had fecal matter in one-third or less of the segment and were considered equivalent to empty (10 dogs, one cat; Figure 3). In nine cases, there was fecal matter compromising up to two-thirds of the descending colon (eight dogs, one cat), while in four cases, luminal fecal matter filled over two-thirds of the descending colon (two dogs, two cats; Figure 4) compromising up to half of the total colon length. If we re-classify the latter four cases as full colons, the total study population would consist of 57 empty colons (47 dogs and 10 cats) and 43 full colons (21 dogs and 22 cats). Consequently, the p-value for the prevalence of empty colons in the total population would increase to 0.162 and become not statistically significant. However, when considering species differentiation, the significance would increase after this requalification, as the p-value for the prevalence of empty colons would decrease (p<0.001).

The interobserver agreement regarding the differentiation between an empty and a full colon was substantial (K=0.80). When assessing the individual colon segments, the agreement was substantial for the ascending colon (K=0.75) and almost perfect for both the transverse (K=0.83) and descending (K=0.83) colon. In terms of classification of the various empty luminal content of each segment, the interobserver agreement was determined to be moderate (K=0.59).

Control group

In the group with gastrointestinal diseases, the age of the dogs ranged from 4 months to 17 years (mean 4 years), and the age of the cats ranged from 4 months to 11 years (mean 2 years). In the non-gastrointestinal disease group, the age of the dogs ranged from 4 months to 15 years (mean 5 years), and the age of the cats ranged from 6 months to 16 years (mean 3 years). The most represented breeds were mixed-breed dogs and European Shorthair cats (for all breeds, see Table S2 and S2). In the gastrointestinal disease group, there were 17 male dogs (56.7%, 11 intact, 6 neutered) and 13 female dogs (43.3%, 2 intact, 11 neutered). The group also included 12 male cats (60%, 3 intact, 9 neutered) and 8 female cats (40%, 1 intact, 7 neutered, with two cats lacking weight specification).

Table 1: Results of the group with small intestinal mechanical obstruction (SIMO) sowing distribution of the SIMO group cases (dog, cat, and total population) into empty and non-empty groups, with further subcategorization of the empty group into acute or chronic, as well as the degree of emptiness (moderate or severe).

	Percentage of total population (%)		
Parameter	**Dog**	**Cat**	**Total population**
Non-empty	19	20	39
	49	12	61
Total acute:	23	5	28
Moderate	5	1	6
Severe	18	4	22
Total chronic:	26	7	33
Moderate	19	4	23
Severe	7	3	10

Table 2: Colon results in the various groups.

Parameter	**Percentage of total population (%)**								
	SIMO			**with GI**			**without GI**		
	Dog**	**Cat****	**Total***	**Dog*****	**Cat*****	**Total***	**Dog**	**Cat**	**Total***
Not empty	28	62.5	39	17	45	36	53	80	66
Empty	72	37.5	61	83	55	64	47	20	34
Acute:									
Moderate	7.4	3.1							
Severe	26.5	12.5							
Chronic:									
Moderate	28	12.5							
Severe	10.3	9.4							

Comparison of the distribution of empty and non-empty colons in the dogs, cats, and the total population of the small intestinal mechanical obstruction (SIMO) group, as well as the two control groups (control group with gastrointestinal (GI) disease and control group without GI disease), showing significant differences between them (*$p<0.001$). Further differentiation into acute and chronic empty colon cases between dog and cat populations revealed a significant difference between the species, with dogs being more likely to present with an empty colon than cats (**$p<0.001$). There was a significant difference between dogs and cats suffering from GI disease (***$p<0.029$). No significant difference between the incidence of acute and chronic cases nor the degree of emptiness between the two species was observed.

The weight distribution ranged from 3 kg to 35 kg in dogs and from 2 kg to 7 kg in cats. The non-gastrointestinal disease group included 17 male dogs (56.7%, 8 intact, 9 neutered) and 13 female dogs (43.3%, 8 intact, 5 neutered), along with 12 male cats (60%, 1 intact, 11 neutered) and 8 female cats (40%, 1 intact, 7 neutered). The weight distribution ranged from 1 kg to 50 kg in dogs and from 3 kg to 8 kg in cats.

In the GI disease group, the most common diagnoses for dogs were enteritis and gastroenteritis, while for cats, it was pancreatitis. In the non-gastrointestinal disease group, the most frequent diagnoses were splenic neoplasia for both dogs and cats, with trauma also being a common diagnosis for cats (for a full list of diagnoses, see Table S4).

All cases with an empty ascending and transverse colon and a fecal-filled colon descendent were reviewed equally to the SIMO group. This led to the requalification of four empty colons as full in the group with gastrointestinal disease and one in the group without gastrointestinal disease. Thus, the control group with GI disease presented 32 cases with an empty colon (64%, p=0.048) and the one without 18 (36%, p=0.048) cases, which both represented a statistically significant result (Table 2). The former group included 21 dogs (70%) and 11 cats (55%) with an empty colon, while the latter included 13 dogs (43%) and 4 cats (20%). The statistical significance was poor in both groups, with a p-value of 0.279 and 0.088, respectively.

The interobserver agreement was substantial in differentiating empty from full colons in both control groups (K=0.80 in the control group with GI disease, K=0.71 in the control group without GI disease). In the assessment of the individual colon segments, the agreement remained substantial in all segments of both groups (control group with GI disease: ascending colon K=0.75, transverse colon K=0.76, descending colon K=0.88; control group without GI disease: ascending colon K=0.68, transverse colon K=0.64, descending colon K=0.81). When considering the luminal content of each segment, the interobserver agreement was moderate in both groups (K=0.48 in the control group with GI disease, K=0.47 in the control group without GI disease).

Discussion

The current study involved 100 dogs and cats with surgically confirmed SIMO. We observed a 61% prevalence of empty colons (collapsed, gas-filled, or a combination of both), while the control group with GI disease had a prevalence of 64% and the one without GI disease of 34%, demonstrating a significant increase in prevalence of an empty colon in patients with SIMO and GI disease in comparison to without. Especially, dogs were more likely to have an empty colon, while cats exhibited a higher proportion of non-empty colons, which was statistically significant in the SIMO group, and observed but not statistically relevant in the control groups. Although the duration of presentation (acute or chronic) did not significantly affect the incidence of empty colons in the overall SIMO population, the colons of the acute cases exhibited a greater degree of emptiness compared to chronic cases.

The SIMO group comprises more dogs (68%) than cats (32%). This uneven distribution can be attributed to the fact that dogs have a higher propensity for intestinal obstruction due to their tendency to ingest foreign objects. Comparative studies involving dogs and cats often have a smaller feline population due to the more limited availability of cases (Hayes, 2009; Elser et al., 2020; Miles et al., 2021). An equal number of cats and dogs in our SIMO study group might have separated the species' differences more significantly.

There is no documented breed predisposition for SIMO (Fossum, 2018), and studies with a similar subject matter have presented with similar dog breed predispositions as in our study (crossbreed and Labrador retrievers) (Drost et al., 2016), as well as with varying ones (Hayes, 2009). This disparity between studies may be attributed to the varying prevalence of breeds across the different geographical locations where the study populations were gathered. Our study's feline breed predilection aligned with that reported in other studies (Hayes, 2009). Most of the animals in our study were under four years of age, consistent with other studies and the tendency of young animals to be more prone to ingesting foreign bodies compared to older animals (Palminteri, 1972; Hayes, 2009; Drost et al., 2016; Fossum, 2018). This aligns with the fact that foreign bodies are the most common cause of SIMO (Gibbs and Pearson, 1973; Slatter, 2002; Zatloukal et al., 2004; Hayes, 2009; Sharma et al., 2011; Nelson and Couto, 2019).

Our findings partially validate our initial hypothesis, revealing a higher proportion of empty colons among patients with SIMO, but additionally also in patients with gastrointestinal disease. The colon is commonly anticipated to be empty in the presence of SIMO (Dennis et al., 2010; Agthe, 2011; Tobias and Johnston, 2018), with small intestinal hyperperistalsis in the acute phase of obstruction contributing to colonic emptying (Lamb and Hansson, 1994). However, there is a paucity of research assessing the colon's appearance in relationship to SIMO in literature (Adams et al., 2010; Lang et al., 2013). In human literature, the bowel distal to the point of obstruction is expected to collapse (Balthazar, 1994; Macutkiewicz and Carlson, 2005; Nicolaou et al., 2005) or be filled with a minimal amount of air (Jackson and Vigiola Cruz, 2018). Computed tomographic studies of the human bowel predominantly describe a reduction in colonic content secondary to intestinal obstruction (Fukuya et al., 1992; Chou et al., 2000; Jackson and Vigiola Cruz, 2018). Triggered by intestinal obstruction, bowel peristalsis in humans increases, often leading to diarrhea and subsequent emptying of the bowel before it ultimately collapses and becomes immobile (Stephenson and Singh, 2011). These findings align closely with our research results. We conclude that the most likely cause for an empty colon secondary to SIMO is the accelerated colonic evacuation by increased intestinal peristalsis distal to the site of obstruction. Similar changes in peristalsis can be expected secondary to other gastrointestinal diseases, supporting the increased prevalence in the control group with gastrointestinal disease. Further research with a larger study population is required to differentiate between the colon presentation and the individual gastrointestinal pathologies.

The absence of significant variation between the acute and chronic SIMO patient groups contradicts the anticipated continuous bowel emptying. Interestingly, the acute cases exhibited greater emptiness than the chronic ones (severe and moderate, respectively). The pathophysiological processes triggered by a mechanical obstruction occur mainly by the obstruction at the site of obstruction or in the intestinal segments orad to it. These processes encompass intestinal motility disorders and absorptive and secretory disturbances (Sleisenger and Fordtran, 1993; Tams, 2003; Liuti, 2010; Ettinger et al., 2017). Sharma's research, comparing SIMO using radiographic and sonographic methods, revealed considerable overlap between hyper- and hypomotility of the gastrointestinal tract in these cases (Sharma et al., 2011), expressing the variable response of the bowel to obstructions. In critically ill patients, colonic motility disorders, such as a reduced colonic tone or megacolon, have been documented (Whitehead et al., 2016), potentially leading to delayed colonic emptying. While it is important to note that our study did not distinguish between the patients' clinical conditions, it could indicate a trend towards colonic hypomotility in more advanced or chronic cases, represented by a fuller colon radiographically. It can be suspected that the colon is emptied in the acute phase and refilled in the chronic phase by the ingesta previously located in the small intestine distal to the obstruction and consecutively stagnating in the colon for a longer period due to colonic hypomotility. Further investigation is warranted to assess the development and progression of local and systemic pathophysiological responses in the distal intestine segments following SIMO, including possible differences between cats and dogs.

Our study classified cases as having an empty colon when at least two colon segments were devoid of content. Considering that the descending colon is nearly as long as the proximal two segments (Evans and Lahunta, 2012), its filling can significantly influence the overall appearance of colon emptiness or fullness. Upon reviewing these particular cases, we found that most of them contained little to less than two-thirds of fecal matter in their lumen and, therefore, remained classified as empty. However, the significance of the prevalence of empty colons in the SIMO group diminished past the *p*-value threshold of significance when we reclassified the five cases with more feces-filled descending colons as non-empty. Interestingly, by re-analyzing the statistical significance of an empty colon for each dog and cat cohort, the significance increased in comparison to the previous calculations. This further supports the significant difference between the two species in assessing colon emptiness in the context of intestinal obstruction. In the control groups, the review of the descending colon led to both groups becoming statistically significant, supporting the differentiation between the groups. However, it lost its statistical significance when differentiating between species. Additional comparative investigations involving a larger population of cats and dogs are needed to assess species disparities comprehensively. Due to this contrasting interspecies presentation in the SIMO group, the evaluation of a dog and cat population as one population might lead to a representation of the species distribution in one population rather than the true prevalence of a pathology.

The disparity of results in the dog and cat population is an interesting and unexpected finding. Cats were more prone to a fecal-filled colon with SIMO than with other gastrointestinal diseases but were particularly prone when not affected by gastrointestinal disease. The authors suspect that the different colonic presentation is related to an extrinsic variable related to the distinct different living habits, environments, and behaviors of dogs and cats rather than a difference in their intestinal pathophysiology. Variables that could influence the colon's appearance could include the time frame between food intake and time of obstruction, the opportunity of intestinal voiding before presentation, which might be more limited for cats usually requiring a litter box, the amount of food intake before obstruction/presentation, the presence of vomiting or diarrhea prior/after obstruction, an active or sedentary lifestyle, body conditioning score differences, encouragement to defecate by the owner after obstruction (e.g., by going on walks), type/size of foreign material and location of intestinal obstruction. Studies with larger populations and including various clinical and environmental variables would be required to better observe and qualify these differences, with some variables requiring a prospective study design.

The agreement between the two observers regarding categorizing the colon as either empty or full exhibited a substantial correlation in all three groups. This positive outcome can be attributed to independently assessing each colon segment as a distinct entity rather than relying on a subjective evaluation of the entire colon's luminal content. Furthermore, the requirement to qualify the luminal emptiness in more detail automatically demanded a meticulous radiographic observation. This methodology not only enhanced the study's quality, precision, and value but also provided measurable and comparable results.

The discrimination between various types of colonic emptiness, including complete collapse, minimal gas content, or a combination of both, may pose an inherent challenge during the assessment process. The small size of an empty colon increases the difficulty in making detailed distinctions (Gibbs and Pearson, 1973), a difficulty also described in a study exploring the use of small intestinal diameter as a diagnostic tool for radiographic diagnosis of mechanical obstruction, in which it was observed that the reproducibility coefficient between observers was least favorable when dealing with a minimal small intestinal diameter (Finck et al., 2014), highlighting the intricacy and limitations of such detailed radiographic distinctions. This likely contributed to the moderate agreement between the observers in all groups.

The level of interobserver agreement was nearly perfect for descending colon in all three groups. In contrast, the ascending and transverse colon exhibited only a substantial level of agreement (exception: transverse colon in the SIMO group was nearly perfect). This variance can be attributed to anatomical factors making the descending colon easier to locate and identify due to its longer length and fixed position towards the pelvis (Evans and Lahunta, 2012) and its preceding transversal segment. In contrast, the ascending colon is the shortest segment and has a more variable position, which can pose challenges regarding precise delineation, especially in cases where pathological small intestine structures are superimposed on it. The presence and superimposition of a significantly gas- or fluid-filled small intestine, which is common in cases of obstruction, can greatly hinder the distinction between the small intestine and the colon (Adams et al., 2010; Agthe, 2011; Trevail et al., 2011; Ettinger et al., 2017). This difficulty has also led to a moderate interobserver agreement in a study examining the colon's radiographic diameter in normal, constipated, and cats with megacolon (Trevail et al., 2011). These findings underscore the possible difficulties and discrepancies encountered by observers in classifying individual, possibly less distinct, colonic segments.

There are several limitations to this study. The small sample size, especially of the cat population, might have limited the ability of the statistic calculations to demonstrate a more significant difference between the species. A sample size calculation was not performed and might have estimated a larger population requirement for more distinct differentiations between species and disease duration. Excluding cases that showed any possibility of luminal patency during surgery leads effectively to the exclusion of obstructions caused by mural or extrinsic pathology, leading to a laboratory bias in favor of foreign body obstruction. Therefore, this study should be taken in this context. The location of the SIMO can significantly impact both its clinical presentation and radiographic appearance (Liuti, 2010) and may also influence the radiographic presentation of the colon (Palminteri, 1972). In the context of our clinical and retrospective study design, the precise location of obstruction along the small intestine could not consistently be defined and, therefore, compared from the surgical reports. The nature of our retrospective study design did not allow exact quantification of the time interval between the onset of obstruction and the radiographic examination, which would have allowed us to track changes in the colon over time and more accurately differentiate between acute and chronic cases. Achieving this level of detail would require a prospective study design. The observers were aware of the patient's diagnosis and complete medical history, potentially introducing a bias in their assessment. However, this was counterbalanced by the inclusion of interobserver agreement calculations.

Conclusions

There is a knowledge gap regarding the aborad response of the small intestine and colon to mechanical obstruction despite extensive research into the pathophysiology of SIMO. Our study yielded noteworthy findings, revealing a higher occurrence of empty colons in SIMO cases among dogs, as well as in dogs and cats with gastrointestinal disease. In contrast, cats exhibited a contrasting pattern, displaying a higher prevalence of non-empty colons in the presence of SIMO. An empty colon can serve as a supportive diagnostic indicator alongside other characteristic radiographic signs for SIMO in dogs or gastrointestinal disease in small animals. These findings open numerous opportunities for future investigations into a pathology routinely encountered in veterinary practices. Further studies might be required to investigate and compare the prevalence of empty colon with mechanical and non-mechanical intestinal obstruction cases.

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Supplementary Materials. See Table S1-S4.

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