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Ulcerative typhlocolitis and peritonitis in cattle due to *Salmonella* spp.

Tiflocolite ulcerativa e peritonite em bovinos por Salmonella spp.

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Abstract

The objective of this study was to report clinical, epidemiological, and anatomopathological data in cattle affected by colitis and perforating ulcerative typhlitis with peritonitis; three (n=3) bovines affected by colitis and two (n=2) with ulcerative typhlocolitis. Clinically, apathy stood out, accompanied by difficulty in exploring the abdominal organs through rectal palpation because of low mobility of the organs due to adhesions. The animals died, and, on necroscopic examination, diffuse, fibrinous purulent peritonitis was recorded due to perforating, multifocal ulcerated areas in the colon and cecum wall. Histopathological examination recorded data compatible with acute, necrotizing, and perforating ulcerative enteritis, with thrombus in the blood vessels associated with fibrinoid necrotizing vasculitis. The immunohistochemistry test for *Salmonella* spp. was positive in four of the five samples analyzed. The etiopathogenesis of perforating ulcerative typhlocolitis in cattle is associated with infection by Salmonella spp., while not ruling out the possibility of participation of other etiologic agents in the occurrence of this disease, due to the complexity of the disease and the scarcity of reports in the literature, further investigations are necessary to provide a better understanding of this disease in cattle.

Resumo

Objetivou-se relatar os dados clínicos, epidemiológicos e anatomopatológicos em bovinos acometidos por colite e tiflite ulcerativa perfurante com peritonite; sendo três (n=3) bovinos acometidos por colite e dois (n=2) com tiflocolite ulcerativas. Clinicamente destacou-se: apatia, acompanhada da dificuldade na exploração dos órgãos abdominais por meio da palpação retal, consequente da pouca mobilidade dos órgãos em função das aderências. Os animais vieram a óbito e, no exame necroscópico, foram registradas peritonite difusa, fibrinopurulenta, em consequência de áreas ulceradas perfurantes, multifocais, na parede do cólon e ceco. Na histopatologia, registrou-se dados compatíveis com enterite aguda, necrosante e ulcerativa por perfuração, com presença de trombos nos vasos sanguíneos, associados à vasculite necrosante fibrinóide. A prova de imunohistoquímica para *Salmonella* spp. foi positiva em quatro das cinco amostras analisadas. A etiopatogenia da tiflocolite ulcerativa perfurante em bovinos está associada à infecção por *Salmonella* spp., não descartando a possibilidade da participação de outros agentes etiológicos na ocorrência desta enfermidade, e em função da complexidade da doença e à escassez de relatos na literatura, são necessárias maiores investigações para que haja uma melhor compreensão a respeito desta enfermidade em bovinos.

Palavras-chave: doença crônica intestinal; enterite; imuno-histoquímica; salmonelose.

1 | Introduction

Intestinal lesions can be defined as the solution of continuity of the mucosa, mucosa and muscle, serosa, or of the three layers of the wall. Although they can present in all intestinal segments, lesions mainly affect the small intestine, cecum, rectum, and less commonly the colon. In cattle, the most common causes are rectal palpation and trauma due to perforating foreign bodies (Dirksen et al., 2005). The main infectious causes of typhlocolitis in this species include salmonellosis, bovine viral diarrhea, coccidiosis, adenovirus, enterovirus, and coronavirus (Blas-Machado et al., 2007; Pavarini et al., 2008; Maxie, 2016).

In humans the etiology of ulcerative colitis is unknown and multifactorial, affecting individuals with genetic predisposition, in which environmental and microbial factors trigger a deleterious immune response (Lapaquette et al., 2012). In this context, ulcerative colitis is part of a group of gastrointestinal inflammatory disorders with immune responses and adverse outcomes of a recurrent character that predominantly affects the colon and rectum (Sung and Park, 2013).

According to Pearl et al. (2013), the etiology of the disease may be due to an inadequate immune response to an environmental factor, such as an intestinal microorganism. A study by Tripathi et al. (2016) found a high association between ulcerative colitis and the presence of Salmonella in humans affected with this disease, indicating that Salmonella may be an etiological agent or may be associated with this disease due to the increased susceptibility to infection, in the function of loss of mucosal integrity. The *Salmonella enterica* infection, subspecies enterica serotype Typhi (*S. typhi*) causes a disease known as typhoid fever, which can lead to perforating ulcerative colitis, a condition associated with a high mortality rate. The pathogenesis of typhoid perforation is poorly understood, including host and bacterial factors, although it has been suggested that its pathology could be mediated by the immune system (Nguyen et al., 2004; Chang et al., 2006).

In cattle, there is a case report associating perforating ulcerative typhlocolitis caused by *Edwardsiella tarda* (Gabriel et al., 2019), and there is also a description of the occurrence of ulcerative colitis and proctitis as a cause of peritonitis in two cows, ruling out the presence of infectious agents (Braun et al., 2015). *Salmonella* spp. is probably the infectious pathogen with the greatest capacity to cause a wide variety of clinical problems in dairy cattle, and the infections caused by this agent are well known for their association with clinical signs of enterocolitis. However, it has not been related to more severe lesions, such as intestinal perforation (Holschbach and Peek, 2018). There is a reported case in which a steer with chronic clinical progression presented severe segmental thickening of the ileum, associated with intestinal rupture and peritonitis, caused by *Salmonella* spp. (Molossi et al., 2021).

In cattle, information on the occurrence of ulcerative typhlocolitis is scarce, and to date there are no reports in the literature that associate infection with *Salmonella* spp. with this condition. Thus, the objective of the current study was to report clinical, epidemiological, and anatomopathological findings in cattle affected by perforating ulcerative typhlocolitis associated with *Salmonella* spp.

2 | Material and Methods

The clinical, epidemiological, laboratory and anatomopathological findings of five cattle, originating from different properties, diagnosed with ulcerative typhlocolitis were analyzed at the Bovine Clinic of Garanhuns, campus of the Federal Rural University of Pernambuco (CBG/UFRPE), in Garanhuns, Pernambuco, Brazil, and at the Veterinary Hospital Adílio Santos de Azevedo (HV ASA) of the Federal Institute of Paraíba (IFPB), in Sousa, Paraíba, Brazil.

The cattle were subjected to clinical examination following the recommendations of Constable et al. (2017). Complementary exams were performed. For the hemogram, blood samples were obtained by venipuncture of the jugular vein to determine hematological variables (blood count, total plasma protein, and plasma fibrinogen), following the methodology proposed by Harvey et al. (2012). Samples of ruminal fluid from three animals were analyzed according to Constable et al. (2017), including the measurement of the chloride content, using a commercial kit (Cloretos®, Labtest Diagnóstica AS). The reading was conducted in a semi-automatic biochemical analyzer (Labquest®, Bioplus Produtos para laboratórios Ltda). All cases resulted in the indication of euthanasia, which followed the protocol according to CFMV (2012), or resulted in death, and necropsies were performed in all cases. Tissue fragments were collected from the

ascending colon of three animals and the cecum of two animals, in addition to other organs (lung, liver, kidney, spleen and small intestine). The samples were stored in 10% buffered formalin before being fixed, routinely processed for histology, stained with hematoxylin and eosin (H&E) and evaluated by optical microscopy.

Immunohistochemistry was performed in all cases. The intestinal fragments were sectioned for assembly on positive slides (Easy-Path©, Erviegas, SP, Brazil). Blocking of endogenous peroxidase was performed by incubating the slides in a 10% solution of hydrogen peroxide in methanol. Antigen recovery was performed with protease XIV (Sigma Chemical Company©, Poole, United Kingdom) for 15min. The slides were incubated with 5% skimmed milk (Molico®) dissolved in distilled water to block nonspecific endogenous proteins. The sections were then incubated with the primary polyclonal anti-*Salmonella* antibody (Biogenesis®) diluted 1: 1000 in phosphate buffered saline (PBS). The amplification signal was achieved using the peroxidase-labeled universal polymer method (MACH 4 Universal HRP-Polumer-Biocare Medical, Pacheco, CA, USA). The reaction was developed with 3-amino-9-ethylcarbazole (AEC, BiocareMedical, Pacheco, CA, USA) and then contrasted with Harris hematoxylin for less than 1min. The previously confirmed positive controls were prepared simultaneously.

3 | Results

Animals of different sexes, ages, and herds were treated. Some clinical signs observed were more common among the cases, such as apathy, anorexia, hypomotile gastrointestinal tract, increased abdominal tension, and, in three of the five cases where rectal palpation was possible, difficulty examining the abdominal organs via this route due to adhesions (Table 1).

Table 1. Main clinical findings observed in cattle (n=5) affected with ulcerative typhlocolitis

Parameters	Animals				
	1	2	3	4	5
Attitude	Standing	Decubitus sternum-lateral	Decubitus sternum-lateral	Standing	Standing
Behavior	Apathy	Apathy	Apathy	Apathy	Apathy
Degree of dehydration (%)	5	10	8	5	5
RT (°C)	39.0	40.7	38.9	38.2	39.3
HR (bpm)	52	128	64	81	88
RR (mrpm)	16	44	32	24	24
Appetite	Capricious	Capricious	Capricious	(-)	(-)
Ruminal motility	(+) (+) low amplitude	Borborygmus	Atonic	(+) - -	Borborygmus
Abdominal tension	↑	↑	↑	Slightly ↑	Slightly ↑
Sound of liquid on 'bumping'	+	-	-	-	-
Rectal palpation	Limited exploration due to possible adherence	Difficulty in exploration due to poor mobility	Difficulty in exploration due to poor mobility	Increased tension, irritated rectal mucosa and congestion	Exploration not possible
Intestinal motility	↓	↓	↓	↓	(-)
Feces*	Small quantity and excessively digested	Scarce Parched	(-)	With the presence of mucus	Diarrheal
Evidence of pain	-	+	nv	nv	-

%: percentage; °C: degrees Celsius; bpm: beats per minute; mrpm: respiratory movements per minute; ↑: increased; ↓: decreased; +: positive; -: negative;(-): Absent; (+); Present and incomplete motility; nv: Not verified. * No blood was observed.

Animal 1, male, crossbreed, adult bovine, reared under semi-intensive management, with a history of apathy and hyporexia for 15 days. The bovine was fed with sugar cane bagasse and corn bran. On physical examination, slight kyphosis, apathy, dysmetria in the pelvic limbs, dragging the hoof axial when walking, and oligopnea breathing were observed. Increased abdominal tension with the sound of liquid that was found after ballooning. In the dorsal pinch test, the animal stopped breathing. Decreased appetite, absence of rumination, empty rumen with undefined stratification, ruminal hypomotility, and discreet tympanic. The abomasum and intestines showed hypomotility; the feces were small and excessively digested. Rectal exploration was quite limited due to adhesions involving the large intestine with the left kidney, rumen, and greater omentum (Table 1).

The hemogram showed leukocytosis due to neutrophilia with a left regenerative shift and hyperfibrinogenemia (Table 2). The ruminal fluid analysis demonstrated significant impairment in the ruminal microbiota and a marked increase in chloride content (Table 3).

Table 2. Hematological parameters of cattle (n=5) affected by ulcerative colitis

Parameters	Animals					Reference Values*
	1	2	3	4	5	
Ht (%)	27	39	32	42	51	24 to 46
He (x10^6)	6.5	9.4	-	9.5	11,0	8.0 to 15.0
Hg (g/dL)	8.3	14.0	-	14.9	15,2	5.0 to 10.0
MCV (fL)	41.8	41.4	-	44.2	46,1	40.0 to 60.0
MCHC (%)	30.7	35.9	-	35.5	30	30.0 to 36.0
Total leukocytes (/µL)	16050	15250	16050	14100	13150	4000 to 12000
Lymphocytes (/µL)	3371	1068	-	4935	11835	2500 to 7500
Neut. Seg. (/µL)	11877	13573	-	6909	527	600 to 4000
Neut. Bast. (/µL)	321	305	-	1833	384	0 to 120
Eosinophils (/µL)	161	152	-	141	394	0 to 2400
Monocytes (/µL)	160	152	-	282	0	25 to 840
Basophils (/µL)	160	0	-	-	0	0 to 200
TPP (g/dL)	7.2	7.1	6.6	6.8	5,0	7.0 to 8.5
PF (mg/dL)	1000	1000	800	800	500	300 to 700

MCV: Mean corpuscular volume; MCHC: Mean corpuscular hemoglobin concentration; TPP: Total plasma protein; PF: Plasma fibrinogen. *Jain (1993).

Table 3. Analysis of ruminal fluid and chloride content (n=3) dosage of bovine affected with ulcerative colitis.

Parameters	Animals			Reference Values*
	1	4	5	
Color	Brownish green	Brownish	Olive green	Varied
Odor	Aromatic	Aromatic	Altered	Aromatic
Consistency	Viscous	Slightly viscous	Aqueous	Slightly viscous
pH	7.0	6.0 - 7.0	7.0	5.5 to 7.4
Protozoa (%)	30	< 10	10	90 to 100
Density	++	+	+	+++
Motility	++	+	++	+++
MBRT (min)	Iv	> 10 min	> 8 min	3 to 6
SFT (min)	Iv	> 10 min	> 8 min	4 to 8
Chloride content (mEq/L)	60	42	43.48	< 30

MBRT: Methylene blue reduction test. SFT: Sedimentation and Flotation Time. Iv: Insufficient Volume. *Constable et al. (2017).

Due to the severity of the case, the animal was euthanized one day after admission. At necropsy, the presence of cloudy peritoneal fluid with fibrin debris was observed. Serosa of the intestine were red with moderate to severe engorgement of blood vessels and showed multiple adhesions between the loops of

the large intestine. Colon mucosa with diffuse fibrin deposition, circular lesions suggestive of necrosis with different depths and multifocal distribution, and perforation caused by ulcerative colitis (Figure 1). Microscopically, there was diffuse mucosal ulceration in the colon, with adherence of cellular debris and fibrin. Adjacent to necrosis, an inflammatory infiltrate consisting of neutrophils, healthy and degenerate, and multifocal intralesional myriad coccoid basophilic bacteria. In the submucosa, fibroblast proliferation, slight neovascularization (granulation tissue), and mild inflammatory infiltrate of neutrophils were observed, in addition to occasional macrophages. Therefore, this was considered a severe diffuse subacute ulcerative colitis, associated with intralesional bacterial myriads. The result of immunohistochemistry using primary polyclonal anti-*Salmonella* antibody was negative.

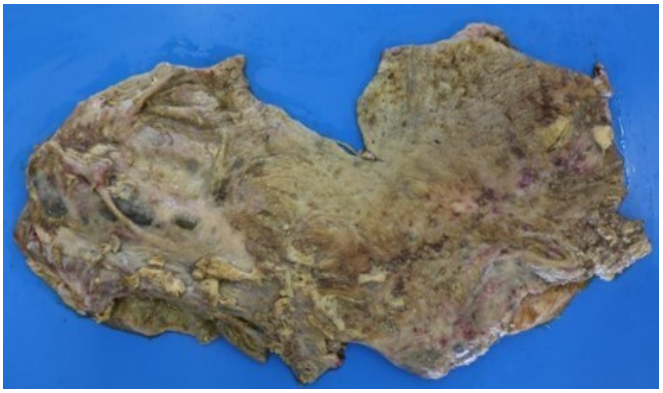

Figure 1. Bovine, ascending colon. Multifocally, there are circular areas of necrosis in the mucosa with diffuse fibrin exudate.

Animal 2, male bovine Holstein, three years of age, reared in a semi-intensive system, with a history of anorexia, apathy, and tremors without improvement after treatment on the farm for three days. The animal was fed with chopped grass, chicken litter, and manioc peel, and received mineralization ad libitum. Physical examination revealed sternum-lateral decubitus, apathy, colic, and dehydration (8%), with difficulty standing up. The abdomen bilaterally distended, tense and with liquid sound to abdominal ballooning. Decreased appetite, atonic rumen, with undefined stratifications, hypomotility abomasum and intestines. It was impossible to progress upon rectal palpation as there was no mobility due to adhesions (Table 1).

In the hemogram, neutrophilic leukocytosis was found with a left regenerative shift and hyperfibrinogenemia (Table 2). The analysis of ruminal fluid showed a brownish fluid, slightly viscous, with pH 7, impairment of the microbiota and chloride of 42.82 mEq/L (Table 3).

The animal died after one day of hospitalization. At the necropsy, there was diffuse fibrinonecrotic peritonitis characterized by a large amount of brown peritoneal fluid with food content and diffuse fibrinous exudate. In the colon, marked diffuse thickening of the wall was found with a focal area of the rupture and a large amount of fibrinous exudate adhered to the mucosa (Figure 2).

Microscopically, diffuse submucosa, muscular, and serous thickening was found due to proliferation of fibroblasts, collagen fibers, and neovascularization (fibroplasia), with multifocal and focally extensive areas of necrosis and moderate neutrophilic multifocal inflammatory infiltrate with macrophages that extend to the adjacent adipose tissue (steatonecrosis). Delimiting the areas of necrosis and permeating the fibroplasia, there was a moderate and multifocal inflammatory infiltrate consisting of neutrophils, macrophages, and occasional foamy macrophages; in addition to multifocal intralesional myriad coccoid basophilic bacteria and mild hemorrhage. This is, therefore, subacute necrosuppurative colitis, focally extensive and accentuated, associated with fibroplasia and myriad bacteria. In immunohistochemistry, strong immunostaining of coccobacilli was observed for *Salmonella* spp. (Figure 3).

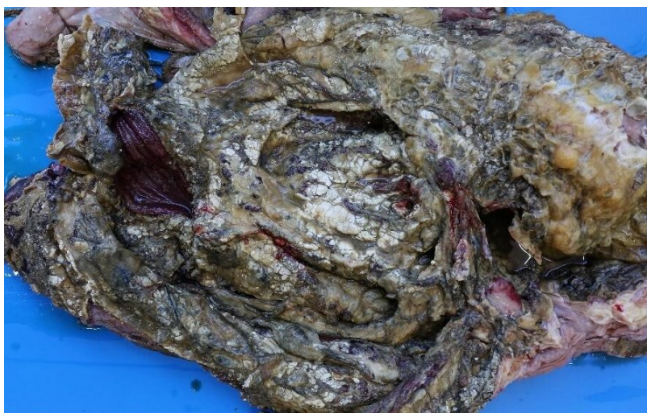

Figure 2. Bovine, ascending colon, multiple segments. Diffusely, there is marked hyperemia with abundant fibrin exudate adhered to the mucosa.

Animal 3, female, mixed breed, five years old was attended at the HV ASA, IFPB, reared in a semi-extensive regime, fed on cane, corn, and grass, twice a day. History of apathy and anorexia and presenting diarrhea and dyskinesia for six days. The cow had

calved 8 days ago. This was the only case on the property. On physical examination, the animal was observed to be apathetic, with slightly congested ocular mucous membranes and slightly increased abdominal tension. Absent appetite, rumen showed atony and hypomotile abomasum. In the rectal palpation, difficulty in exploring the abdominal organs was found, the rectal mucosa was congested with mucus in the feces (Table 1). The hemogram revealed leukocytosis, hypoproteinemia, and hyperfibrinogenemia (Table 2).

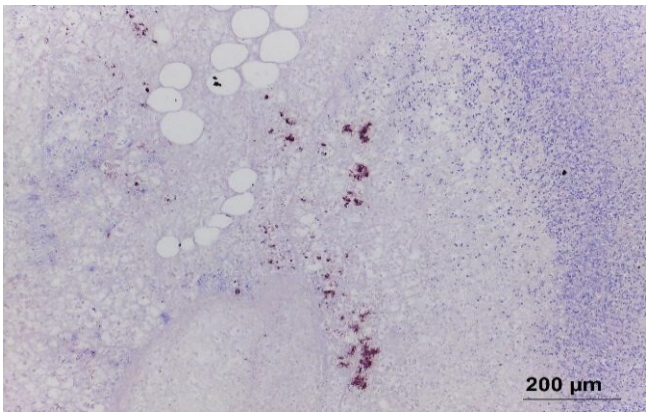

Figure 3. Bovine, ascending colon. Immunohistochemistry, strong immunostaining for *Salmonella* spp. (Obj. 10x)

Two days after admission, the animal died. At necropsy, yellowish and fibrillar fluid associated with free vegetable fibers were observed in the abdominal cavity with adherence of the omentum and serosa to the intestinal loops. The serosa of the large intestinal loops was thickened by yellowish and fibrillar material and in the mucosa in the cecum, colon, and rectum, ulcerative lesions were observed, multifocal to coalescing, ranging from two to five centimeters in diameter, characterized by a depressed and reddish surface, sometimes covered by greenish and grayish exudate. In the cecum, a focal area of transmural perforation of approximately 2 centimeters in diameter was observed on the periphery, with marked hyperemia, and fibrin-suppurative exudate (Figure 4).

Histologically, moderate to severe multifocal to coalescing fibrinonecrotic enterocolitis was observed. The lesions were more accentuated in the cecum and were characterized by multifocal areas with coalescing mucosal necrosis, extending to the submucosa associated with hemorrhage, fibrin, and inflammatory infiltrate consisting mainly of neutrophils, lymphocytes, and plasma cells. The blood vessels of the submucosa were congested and some contained thrombi. The serosa was diffusely thickened by strongly eosinophilic and abundant fibrillar material associated with inflammation and myriads of basophilic coccoid aggregates (Figure 5). Similar lesions were observed in the colon and rectum. In immunohistochemistry, moderate immunostaining of coccobacilli was observed for *Salmonella* spp.

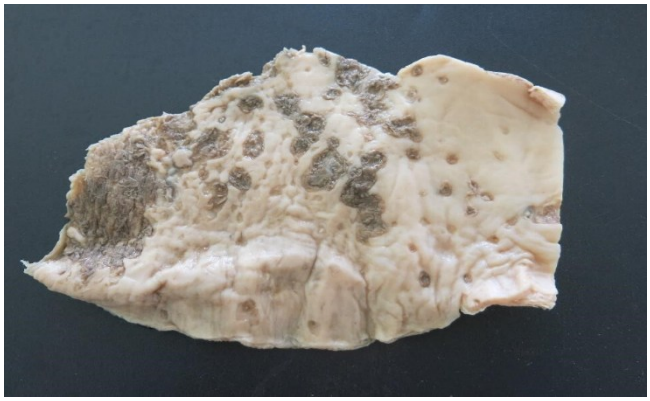

Figure 4. Bovine, cecum (fixed in formalin). In the mucosa, multifocal to coalescent areas of ulceration.

Animal 4, female bovine, Holstein, 10 months old, reared in an intensive system, presenting apathy and anorexia. The bovine was fed with hay, corn bran, soy bran, and cottonseed and received mineralization ad libitum. On physical examination, it was found that the animal was standing, apathy, with a temperature of 39.3°C, congested mucous membranes, injected episcleral vessels, tachycardia, inappetence, absence of rumination, slightly increased abdominal wall tension, ruminal hypomotility, diarrheal stools, fetid, and poorly digested (Table 1). It was not possible to perform rectal exploration due to the size of the animal.

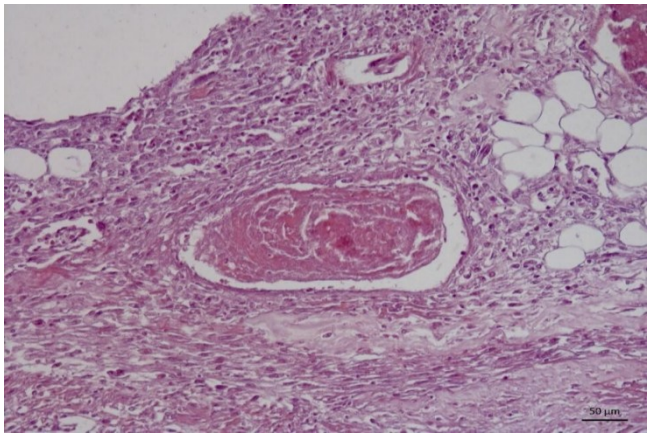

Figure 5. Bovine, cecum. Large fibrin thrombi in the submucosa. Hematoxylin-eosin (H&E – Obj. 40X).

Hemogram with neutrophilia and marked regenerative left shift (Table 2). Analysis of the ruminal fluid revealed that it was an aqueous, olive-green fluid with an altered odor, pH 7, microbiota impairment and 43.48 mEq/L chloride content (Table 3).

After six days of hospitalization, euthanasia was performed due to the unfavorable prognosis. At necropsy, a large amount of greenish yellow and intensely turbid free fluid was observed in the abdominal cavity, associated with free vegetable fibers, in addition to a moderate to marked amount of fibrinous exudate adhered to the serosa of the gastrointestinal tract, predominantly in the large intestine region. Ulcerative colitis was observed in the ascending colon segment, resulting in leakage of intestinal contents into the abdominal cavity. In the mucosa adjacent to this laceration, there were focal areas of extensive loss with deposition of discrete fibrinous exudate and blackened periphery (Figure 6).

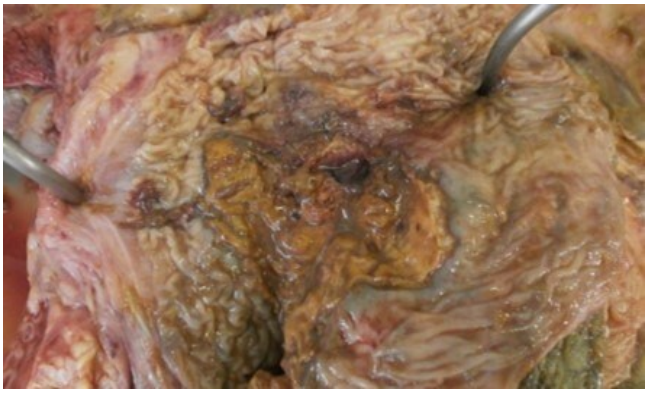

Figure 6. Bovine, ascending colon. Extensive area of necrosis adjacent to perforated focal ulcer in the mucosa.

The histopathological examination of the colon fragment revealed a focal area of markedly extensive submucosa expansion through large areas of accumulation of fibrinous exudate, surrounded by intense lymphohistiocytic inflammatory infiltrate with neutrophils and occasional foci of fibrosis. In addition, a marked expansion in serosa with the proliferation of young fibroblasts producing an organized fibrovascular matrix (granulation tissue), marked dilation of lymphatic vessels, and a large amount of cellular, neutrophil, and amorphous eosinophilic tissue in the surface region. Focally extensive area of diffuse mucosal loss, containing a slight amount of cellular debris and plant material. In immunohistochemistry, weak immunostaining of coccobacilli was observed for *Salmonella* spp.

Animal 5, female, crossbred, adult bovine, raised in a semi-intensive system, with a history of parturition for two days, without apparent complications and having as a product a live and full-term fetus, in addition to having eliminated the placenta. However, the animal showed apathy the next day, in addition to feces with large amounts of blood. It fed on grass, forage palm, corn bran, soy bran, cotton bran and received mineralization at will. It was not possible to carry out a complete physical examination, as the animal died before the clinical examination. However, it was possible to collect a sample to perform the blood count. This exam revealed leukocytosis due to lymphocytosis, neutropenia, hypoproteinemia and hyperfibrinogenemia (Table 2).

At necropsy, the presence of reddish colored fluid in the abdominal cavity was observed, with adherence of the omentum and serosa of the intestinal loops. The serosa of the intestinal loops was thickened by yellowish and fibrillar material. There was extensive perforation of the cecum wall. The organ's mucosa was congested and swollen, with multifocal ulcers. In the colonic mucosa, ulcerative lesions of varying size were observed, with transmural perforation. In the mucosa adjacent to the lacerations, there were focally extensive areas of epithelial loss with deposition of fibrinous exudate (Figure 7).

Microscopically, in the colon, multifocal areas of necrosis covered by cellular debris and abundant deposition of strongly eosinophilic and fibrillar material in the mucosa were observed. The areas of necrosis were surrounded by a marked inflammatory infiltrate composed of intact and degenerated neutrophils associated with vascular congestion (Figure 8) and edema, sometimes with fibrinoid necrosis of the blood vessel wall, hypertrophy of endothelial cells and thrombi. There was a focal area of transmural necrosis surrounded by an inflammatory infiltrate similar to that described above. Amidst the areas of necrosis, basophilic bacterial aggregates in the form of rods were seen. Adjacent to necrosis, distension of the lamina propria was observed due to a mononuclear inflammatory infiltrate composed of lymphocytes, plasma cells and macrophages. In the lumen of some crypts there was a mild neutrophilic inflammatory infiltrate (crypt abscesses). In immunohistochemistry, strong immunostaining of coccobacilli was observed for *Salmonella* spp.

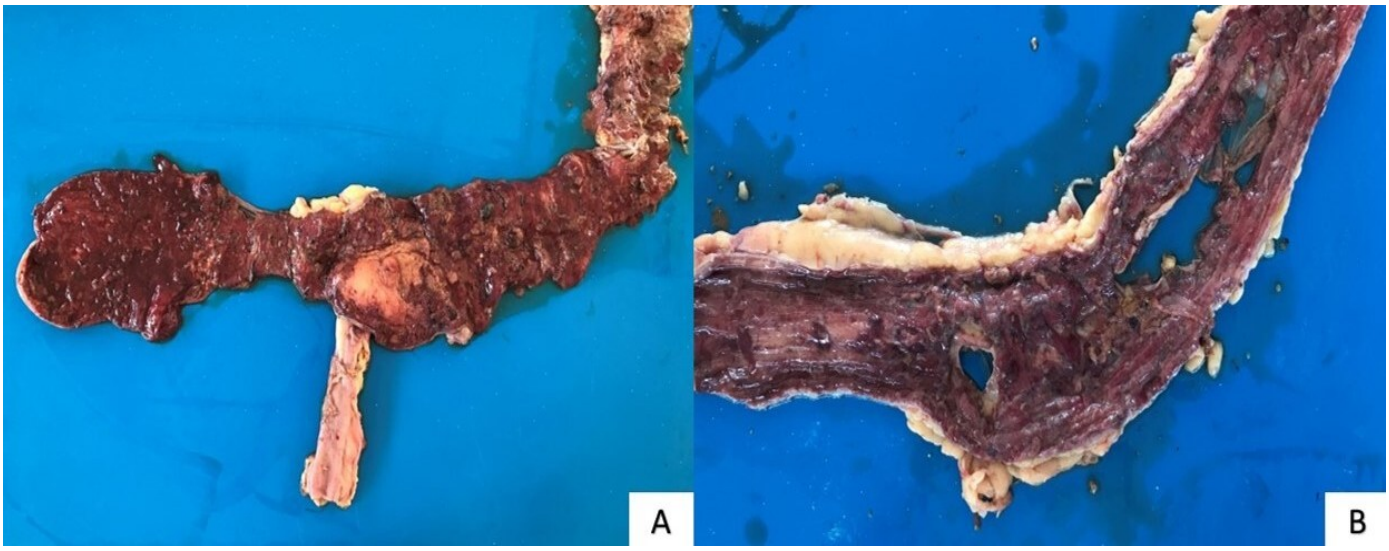

Figure 7. (A) Bovine, cecum. In the mucosa focally extensive hyperemia and multifocal areas of necrosis. Bovine, colon. (B) Multiple perforated ulcers in ascending colon.

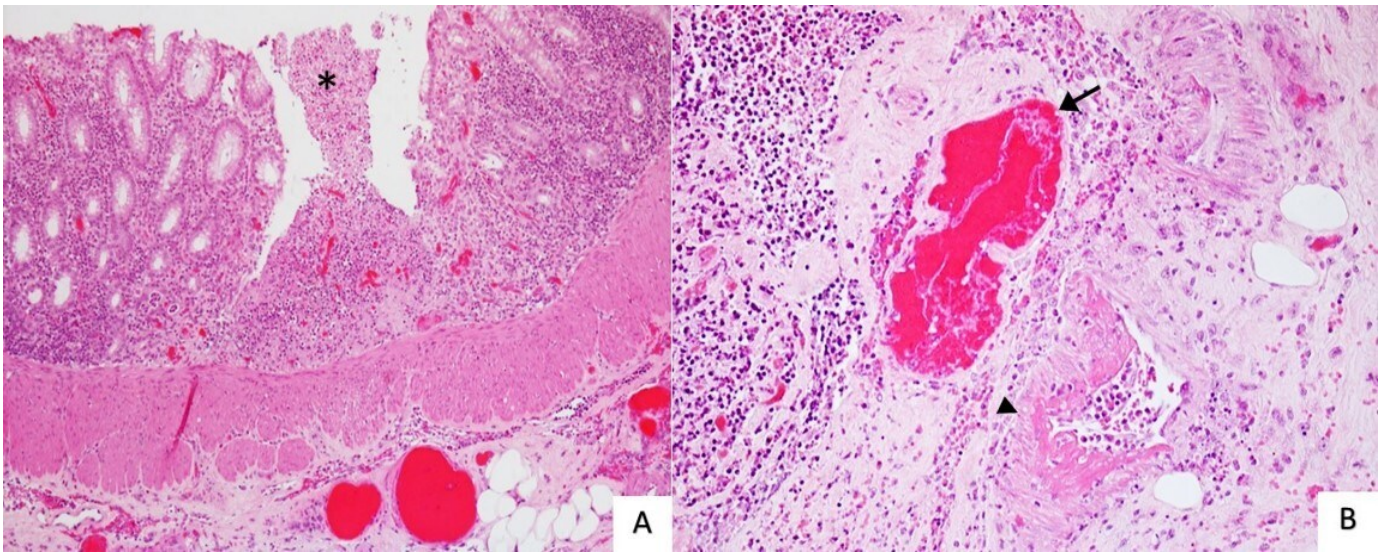

Figure 8. (A) Bovine, colon. A focal area of necrosis (asterisk) covered by cell debris and fibrin deposition is observed, surrounded by a neutrophilic inflammatory infiltrate associated with vascular congestion in the mucosa. H&E, 20x. (B) Colon. Fibrinoid necrosis (arrowhead) and congestion (arrow) are seen in blood vessels adjacent to the area of necrosis. H&E, 40x.

4 | Discussion

The clinical findings were common among the reported cases, with emphasis on apathy, anorexia, impaired ruminal function, increased abdominal tension, and, especially, the difficulty in exploring the abdominal organs through rectal palpation because of lack of mobility due to adhesions. These findings are similar to those reported by Braun et al. (2015), who also found the impossibility of manipulating the intestine through rectal palpation in cattle affected by non-traumatic ulcerative rectocolitis, ratifying the importance of rectal palpation as a diagnostic aid for this type of clinical entity in cattle. The other clinical manifestations, although not as specific, proved to be significant as an indication of the impairment in the general condition of the animals.

Regarding the leukocyte response found, neutrophilic leukocytosis, in addition to the increase in plasma fibrinogen, is due to the inflammation in response to events modulated by chemical mediators at the injury site. Peritonitis due to intestinal rupture, as observed in the cases reported herein, can lead to high consumption of neutrophils, which exceeds the production capacity of the bone marrow, causing a left shift (Thrall et al., 2015). This explains the fact of the significant neutrophilia and hyperfibrinogenemia found. In addition, in cases in which the differential

leukocyte count was performed, a regenerative left shift was observed, which further demonstrates the severity of the inflammatory condition in these animals. This condition is similar to the report presented by Braun et al. (2015), however, in the current study, one of the cattle showed neutropenia, probably because it presented a more acute condition.

Alterations in the ruminal fluid of animals 1, 4, and 5, affecting physicochemical parameters and microbiota, were probably secondary to the hyporexia/anorexia observed in these animals, as suggested by Afonso et al. (2002). Causes such as peritonitis, paralysis of the large or small intestine, and mechanical obstructions of the intestine, among others, can increase the chloride content in the ruminal fluid of cattle. This occurs due to the reflux of hydrochloric acid–rich abomasal content into the proventriculus, resulting from impaired flow (Silva Filho et al., 2010; Constable et al., 2017). Therefore, the sharp increase the chloride content present in the rumen fluid of these animals was probably due to an intestinal transit disorder of mechanical origin, caused by adhesions due to peritonitis.

The macroscopic findings are similar to those reported by Braun et al. (2015) and Gabriel et al. (2019), in cases of colitis, proctitis and typhlocolitis in cows, who found diffuse, fibrinopurulent peritonitis as result of perforating, multifocal ulcerated areas in the colon and rectum wall. Bacterial peritonitis can occur when the bacteria present at a contaminated external surface, reach the peritoneum by contiguous lesion. Most commonly, this originates from peritoneal contamination through perforation or rupture of the gastrointestinal tract. In cattle, acute diffuse fibrinopurulent peritonitis is common and usually results from visceral perforation, including the gastrointestinal or reproductive tract. Perforation initially results in acute local disease, which is often followed by diffuse chronic peritonitis with adhesions (Maxie, 2016). The histological findings corroborate those described by Braun et al. (2015) and Gabriel et al. (2019), who characterized acute, necrotizing, and ulcerative perforation, with the presence of thrombi in the blood vessels, associated with fibrinoid necrotizing vasculitis, in addition to the presence of myriad bacterial lesions.

Typhlitis and colitis can be part of enterocolitis involving the small and large intestine, or they can be regional and limited to any specific segment or segments of the intestine. The damaged colonic mucosa can serve as a gateway for the translocation of bacteria or toxins. In cattle, salmonellosis, bovine viral diarrhea, coccidiosis, enterovirus, adenoviral infection, winter dysentery (coronavirus) and Edwardsiella tarda are diseases commonly associated with typhlocolitis (Blas-Machaado et al., 2007; Pavanini et al., 2008; Maxie, 2016; Gabriel et al., 2019).

Specifically, in the chronic enteric form of salmonellosis, lesions associated with well-demarcated foci of necrosis and mucosal ulceration in the cecum and colon can occur, which are derived from damage to the vascular system, due to the development of vasculitis and throm bosis associated with the spread of bacterial toxins in the intestinal submucosa (Gelberg, 2013).

In the current study, the immunohistochemistry test for *Salmonella* spp. was positive in four of the five samples analyzed. With this, we can infer that this bacterium may be involved in the pathogenesis of ulcerative colitis in cattle. However, in the work carried out by Braun et al. (2015) no involvement of any infectious etiologic agent was identified in ulcerative colitis in cattle, ruling out mycobacteriosis, adenovirus, malignant bluetongue, mycosis, and parasitic infestation (such as coccidiosis), as well as salmonellosis and bovine viral diarrhea.

In the sample with a negative result in the standard immunohistochemistry test, microscopic lesions similar to those of positive samples were observed and the presence of intralesional bacterial myriads was also found. According to Chassaing and Darfeuille-Michaud (2011), there is evidence to indicate dysbiosis or the presence of a pathogen as mediators of the pathogenesis of ulcerative colitis in humans, however there is not necessarily a specific pathogen. With this, we can infer that *Salmonella* spp. does not seem to be the only agent involved in the occurrence of this disease in cattle.

In humans, according to Campieri and Gionchetti (2001), some bacteria are present in the intestinal mucosa and can act by degrading its protective structure, leading to its invasion, and therefore, in the absence of bacteria, there is no ulcerative colitis. According to those authors, some bacteria are in the intestinal mucosa and can act by degrading its protective structure, leading to its invasion.

However, the unanswered question is whether chronic recurrent inflammation is the result of persistent infection with a specific pathogen,

overexposure to saprophytic bacteria products due to increased intestinal permeability or altered mucus composition, or to an exacerbated immune response to luminal components and leading to the ulcerative lesions observed. In intestinal models of chronic tissue inflammation, injury, and ulceration, excess production of TNF-α by activated macrophages promotes the production of matrix degrading enzymes, loss of mucosal integrity, and ulceration (Macdonald et al., 2000). This occurs in the destruction of the mucosa in human inflammatory bowel disease and similar mechanisms may occur during infection with *Salmonella* spp. in cattle, leading to ulcerative colitis in these animals.

Ulcerative typhlocolitis causes severe digestive disorders in cattle, leading to severe peritonitis and, consequently, the death of the animals. Its etiopathogenesis may be associated with infection by *Salmonella* spp., while not ruling out the possibility of the participation of other etiologic agents in the occurrence of this disease. Due to the complexity of the disease and the scarcity of reports in literature, further investigations are necessary for better understanding of the etiology of ulcerative colitis in cattle.

5 | Conflict of interests

The authors declare no conflict of interest.

6 | References

Afonso, J.A.B.; Mendonça, C.L.; Costa, N.A.; Souza, M.I.; Simão, L.C.V.; Dantas, F.R. Alterações clínicas e laboratoriais na dilatação do ceco em bovinos. Análise de 10 casos. **Revista de Educação Continuada em Medicina Veterinária e Zootecnia do CRMV-SP**, 5(3): 313–320, 2002.

Blas-Machado, U.; Saliki, J.T.; Boileau, M.J.; Goens, S.D.; Caseltine, S.L.; Duffy, J.C.; Welsh, R.D. Fatal ulcerative and hemorrhagic typhlocolitis in a pregnant heifer associated with natural bovine Enterovirus Type-1 infection. **Veterinary Pathology**, 44(1): 110–115, 2007.

Braun, U.; Hilbe, M.; Gerspach, C.; Ruetten, M. Ulcerative colitis and proctitis in two Swiss Braunvieh cows. **Schweiz Arch Tierheilkd**, 157(4): 203–208, 2015.

Campieri, M.; Gionchetti, P. Bacteria as the cause of ulcerative colitis. **Gut (Gastroenterology and Hepatology)**, 48(1): 132–135, 2001.

CFMV - **Guia brasileiro de boas práticas em eutanásia em animais - Conceitos e procedimentos recomendados**. Brasília, 2012. Available at: <https://www.gov.br/agricultura/pt-br/assuntos/producao-animal/arquivos-publicacoes-bem-estar-animal/guia-brasileiro-de-boas-praticas-para-a-eutanasia-em-animais.pdf>. Accessed on: 20 Jan. 2025.

Chang, Y.T.; Lin, J.Y.; Huang, Y.S. Typhoid colonic perforation in childhood: A ten-year experience. **World Journal of Surgery**, 30(2): 242–247, 2006.

Chassaing, B.; Darfeuille–Michaud, A. The commensal microbiota and enteropathogens in the pathogenesis of inflammatory bowel diseases. **Gastroenterology**, 140(6): 1720- 1728. 2011.

Constable, P.D.; Hinchcliff, K.W.; Done, S.H.; Grunberg, W. **Veterinary medicine: a textbook of the diseases of cattle, horses, sheep, pigs, and goats**. 11th ed. St. Louis: Elsevier, 2017. 2278p.

Dirksen, G.; Gründer, H.; Stöber, M. **Medicina interna y cirugía del bovino**. 4th ed. Buenos Aires: Inter-Médica, 2005. 1272p.

Gabriel, M.E.; Henker, L.C.; Gris, A.; Carneiro, C.; Casagrande, R.A.; Gomes, T.M.A.; Santos, D.M.; Mendes, R.E. Typhlocolitis by *Edwardsiella tarda* in a cow. **Acta Scientiae Veterinariae**, 47(1): 4–8, 2019.

Gelberg, H.B.; Zachary, J.F. Sistema alimentar, peritônio, omento, mesentério e cavidade peritoneal. In: Zachary, J.F.; Mc Gavin, M.D. **Bases da patologia em veterinária**. 5th ed. Rio de Janeiro: Elsevier, 2013, p. 378-379.

Harvey, J.W. Hematology procedures. In: Harvey, J.W. (ed.) **Veterinary hematology. a diagnostic guide and color atlas**. St. Louis: Elsevier, 2012. p. 11–32.

Holschbach, C.L.; Peek, S.F. *Salmonella* in dairy cattle. **Veterinary Clinics of North America - Food Animal Practice**, 34(1): 133–154, 2018.

Jain, N.C. **Essentials of veterinary hematology**. 1st ed. Philadelphia: Lead and Febigar, 1993. 417p.

Lapaquette, P.; Brest, P.; Hofman, P.; Darfeuille-Michaud, A. Etiology of Crohn's disease: many roads lead to autophagy. **Journal of Molecular Medicine**, 90(1): 987–996, 2012.

Macdonald, T.T.; Monteleone, G.; Pender, S.L.F. Recent developments in the immunology of inflammatory bowel disease. **Scandinavian Journal of Immunology**, 51(1): 2–9, 2000.

Maxie, G. **Jubb, Kennedy, and Palmer's pathology of domestic animals**, 6th ed. St. Louis: Elsevier, 2016. 798p.

Molossi, F.A.; Cecco, B.S.; Henker, L.C.; Vargas, T.P.; Lorenzett, M.P.; Bianchi, M.V.; Lorenzo, C.; Sonne, L.; Driemeier, D.; Pavarini, S.P. Epidemiological and pathological aspects of salmonellosis in cattle in southern Brazil. **Ciência Rural**, 51(3): e20200459, 2021.

Nguyen, Q.C.; Everest, P.; Tran, T.K.; House, D.; Murch, S.; Parry, C.; Connerton, P.; Phan, V.B.; To, S.D.; Mastroeni, P.; White, N.J.; Tran, T.H.; Vo, V.H.; Dougan, G.; Farrar, J.J.; Wain, J. A clinical, microbiological, and pathological study of intestinal perforation associated with typhoid fever. **Clinical Infectious Diseases**, 39(1): 61–67, 2004.

Pavarini, S.P.; Bezerra Junior, P.S.; Santos, A.S.; Pescador, C.A.; Brandão, P.E.; Souza, S.P.; Driemeier, D. Achados clínico patológicos durante um surto de disenteria de inverno em bovinos no Rio Grande do Sul. **Pesquisa Veterinária Brasileira**, 28(12): 611–616, 2008.

Pearl, D.S.; Pearl, K.S.; Mark, A.W.; Harriet, N.S.; James, F.B.; Janis, K.S.; Timothy, M.T. Cytokine mucosal expression in ulcerative colitis, the relationship between cytokine release and disease activity. **Journal of Crohn's and Colitis**, 7(6): 481–489, 2013.

Silva Filho, A.P.; Afonso, J.A.B.; Souza, J.C.; Costa, N.A.; Mendonça, C.L. Análise clínica e patológica em 20 casos de intussuscepção em bovinos. **Veterinária e Zootecnia**, 17(3): 421–430, 2010.

Sung, M.; Park, M. Nutrition modulator of ulcerative colitis: clinical efficacies and mechanistic view. **World Journal of Gastroenterology**, 19(7): 994–1004, 2013.

Thrall, M.A. Weiser, G.; Allison, R.W.; Campbell, T.W. **Hematologia e bioquímica clínica veterinária**. 2nd ed. Rio de Janeiro: Guanabara Koogan, 2015. 1590p.

Tripathi, M.K.; Pratap, C.B.; Dixit, V.K.; Singh, T.B.; Shukla, S.K.; Jain, A.K.; Nath, G. Ulcerative colitis and its association with *Salmonella* species. **Interdisciplinary Perspectives on Infectious Diseases**, 2016: 5854285, 2016.