Retrospective Clinical Study of Rumen Foreign Body Syndrome in Small Ruminants: Diagnostic Approach and Outcomes from a Veterinary Teaching Hospital Case Series (2016-2022)

GIULIA SALA[1, 2*], FRANCESCA CROSTA[3], ELISA GAZZOLA[3], LINDA UCCI[3], VINCENZO FERRULLI[3], ANTONIO BOCCARDO[3], DONATELLA DE ZANI[3], DAVIDE PRAVETTONI[3]

[1] Department of Veterinary Sciences, University of Pisa, via Livornese s.n.c., San Piero a Grado, 56122, Italy
[2] Centro di Ricerche Agro-ambientali "E. Avanzi", University of Pisa, San Piero a Grado (PI), 56122, Italy
[3] Department of Veterinary Medicine and Animal Sciences, University of Milan, via dell'università 6, 26900, Lodi, Italy

ABSTRACT

Rumen foreign body syndrome is an underdiagnosed condition in small ruminants due to its nonspecific clinical presentation and the limited availability of literature on the subject. This retrospective study aims to describe the clinical, laboratory, imaging, and necropsy findings associated with rumen foreign bodies in sheep and goats hospitalized at the Veterinary Teaching Hospital of Lodi between September 2016 and March 2022. Medical records of all small ruminants admitted during this period were reviewed, and cases with a final diagnosis of rumen foreign body syndrome were included. Data collected included anamnesis, clinical presentation, laboratory findings, ultrasonography, radiography, treatment, follow-up, and necropsy outcomes. Out of 348 cases, 15 animals were diagnosed with rumen foreign body syndrome. Of these, 9 died and 6 recovered. The most significant clinical finding was altered ruminal motility, observed in 80% of cases, often in association with ruminal atony, tympany, and abdominal distension. Hypothermia was identified as a negative prognostic factor. Blood gas analysis, performed in 11 animals, revealed acid-base imbalance in 8 cases (73%) and hyperlactatemia in 7. Radiography was diagnostic in all 7 animals in which it was performed. In 5 of the 9 deceased animals, the diagnosis was established only at necropsy. Most foreign bodies consisted of plastic materials; less frequently, bezoars or ropes were found. This study highlights the importance of integrating anamnesis, clinical examination, and imaging, particularly radiography, for the timely diagnosis and management of rumen foreign body syndrome in small ruminants.

KEY WORDS

Rumen foreign body; small ruminants; sheep; goats.

INTRODUCTION

Rumen foreign body syndrome is a condition observed in domestic ruminants resulting from the ingestion of indigestible or non-nutritive materials, which subsequently accumulate within the forestomaches [1]. While this syndrome is well-documented in cattle, there is a paucity of studies focusing on its occurrence and clinical presentation in small ruminants such as sheep and goats [2-4]. The ingestion of foreign bodies can lead to a spectrum of clinical signs, ranging from mild digestive disturbances to severe systemic illness and, in some cases, death [2, 5]. Nonspecific symptoms, including anorexia, decreased productivity, weight loss, abdominal distension, and changes in fecal consistency, often complicate early diagnosis. Additionally, the presence of foreign bodies can result in metabolic disturbances and predisposes affected animals to secondary diseases such as rumenitis [6, 7].

Several factors predispose small ruminants to the ingestion of foreign materials, including poor nutritional management, inadequate storage of feed, environmental contamination, and, in certain cases, nutritional deficiencies leading to pica. Although sheep and goats are generally considered more selective feeders compared to cattle, they are not immune to the risk, especially in resource-limited settings or in cases of improper husbandry [2].

The diagnosis of rumen foreign body syndrome is challenging due to the nonspecific nature of clinical and laboratory findings. In bovine, imaging techniques such as ultrasonography and radiography have become essential diagnostic tools. Radiography, in particular, has proven to be the gold standard for intra-vitam diagnosis, allowing definitive identification of foreign objects within the rumen [8].

The present study retrospectively analyses cases of rumen foreign body syndrome in sheep and goats hospitalized at a university veterinary hospital over a six-year period. The aim is to identify common clinical, laboratory, and imaging features, with the goal of improving early diagnosis and clinical outcomes for this underrecognized condition in small ruminants.

*Corresponding Author:
Giulia Sala (giulia.sala@unipi.it)

MATERIALS AND METHODS

Study Design

A retrospective study was conducted on small ruminants (sheep and goats) admitted to the Ruminant and Swine Clinic of the Veterinary Teaching Hospital of Lodi, Italy, between September 2016 and March 2022. The medical records of all hospitalized small ruminants during this period were reviewed. Only cases with a final diagnosis of rumen foreign body syndrome were included in the study.

Data Collection and Analysis

For each included animal, data were collected regarding species, age, production purpose, history, clinical presentation at admission, concurrent diseases, laboratory results, diagnostic imaging, treatment, outcome, and necropsy findings.
Medical records with incomplete information on signalment, history, or clinical examination at admission were excluded from the study. The type of foreign body recovered was described for each case, and the relative percentages were indicated.

Statistical analysis

Data were categorized (Table 1 and 2) and frequencies and percentages were calculated for categorical variables. For each ancillary examination, the frequency of use for diagnostic purposes and its diagnostic value were assessed. Additionally, variables were analysed according to the outcome (survived vs deceased animals). For continuous variables, distribution was assessed using the Shapiro-Wilk test. Median differences between survivors and non-survivors were evaluated using the Mann-Whitney U test. For categorical variables, the possible differences of the outcome were evaluated using chi-square test. Statistical significance was set at $p < 0.05$.

RESULTS

A total of 348 medical records of small ruminants admitted to the Veterinary Teaching Hospital of Lodi between September 2016 and March 2022 were reviewed. Of these, 15 animals (sheep and goats) met the inclusion criteria with a confirmed diagnosis of rumen foreign body syndrome, either during hospitalization or at necropsy. A total of 14 patients (93.33%) were goats, while only 1 (6.66%) was a sheep. Of the 15 animals included in the study, 11 (73.33%) were adults (older than 24 months), and 4 (26.66%) were young animals (younger than 24 months). The mean age of the patients was 60 months (minimum: 5 months; maximum: 130 months; 25th percentile: 24; 75th percentile: 108).
Follow-up data showed that 9 animals (60%) died, while 6 (40%) recovered and were subsequently discharged. All animals included in the study were companion animals.
History revealed that the most frequently reported signs and symptoms at the time of admission by the owner were depressed mental status (10/15; 66.66%), abdominal distension (8/15; 53.33%), and weight loss (7/15; 46.66%). In addition, all animals (15/15; 100%) had a history of ingesting easily fermentable carbohydrates. No differences were underlined between survived and non-survived animals for the history information ($p = 0.564$).

Table 1 - Categories of history of signs reported by the animal owners. This standardized structure was used for the statistical analysis of the history findings.

Categories of history	Description Reported by the Owner
Abnormal behavior	Reluctance to move Prolonged recumbency Weakness Decreased vitality
Abdominal distension	The animal appears bloated The animal seems to have something in the abdomen
Weight loss Ingestion of easily fermentable carbohydrates	The animal has lost weight recently The animal had access to large amounts of bread The animal feed was intended for another species (e.g., flaked feed formulated for horses) The animal is fed with swine mash
Owner-administered home treatments	Oil Brewer's yeast Vitamins Corticosteroids
Anorexia	Fussy appetite The animal eats less than usual The animal did not eat
Hypothermia	The extremities feel cold to the touch The animal is trembling
Alopecia	The animal has areas of sparse hair and crusty skin A lot of hair is found in the animal's environment
Opisthotonus	The animal stands still and rigid The animal looks upward with neck extended
Nasal regurgitation	Discharge of feed material from the nostrils

Clinical examination findings were categorized according to a standardized clinical scoring system based on the framework proposed by Pugh and Baird (2011) [9]. Each parameter was assigned a score reflecting increasing severity or deviation from normal physiology. The frequency of each clinical finding, stratified by survival outcome, is reported in Table 3. Most patients (12/15; 80%) presented in a quadrupedal stance, while 3 out of 15 (20%) were in sternal recumbency, reluctant or unable to rise even when stimulated. All patients discharged in good condition were able to stand at admission, whereas among the deceased animals, 6 were standing (66.66%) and 3 (33.33%) were recumbent ($p = 0.441$). Behavioural assessment showed that 46.66% (7/15) of the animals were alert (score 0), 33.33% (5/15) displayed depressed mental status (score 1), and 20% (3/15) were comatose (score 2). Comatose patients were exclusively among the non-survivors. The presence of alert behavior tended to be more frequent in survivors, though not significantly ($p = 0.148$).

Regarding the nutritional status, most animals (11/15; 73.33%) were in normal body condition (score 0), 20% (3/15) were cachectic (score 1), and one animal (1/15; 6.66%) was obese (score 2) ($p = 0.589$). Dehydration was observed in 20% (3/15) of the cases (score 1), exclusively among non-survivors ($p = 0.059$).

Table 2 - Categorization of clinical examination parameters and corresponding descriptions, based on the clinical assessment framework described by Pugh and Baird (2011) [9]. This standardized structure was used for the statistical analysis of the physical examination findings.

Parameter	Score	Description of categories
Posture	0	Standing
	1	Sternal recumbency
	2	Lateral recumbency
Behavior	0	Alert
	1	Depressed mental status
	2	Comatose state
Nutritional status	0	Normal weight
	1	Cachectic
	2	Obese
Hydration status	0	Normally hydrated
	1	Dehydrated
Thoracic auscultation	0	Absence of abnormal lung sounds
	1	Presence of abnormal lung sounds
Episcleral vessels	0	Not injected
	1	Injected
Mucous membranes	0	Pink
	1	Pale
	2	Icteric
	3	Cyanotic
Jugular veins	0	Normally filled
	1	Collapsed
Nervous system and sensory organs	0	Reflexes preserved
	1	Comatose state (absence of reflexes)
	2	Opisthotonus
	3	Ataxia
	4	Nystagmus
Appetite	0	Present
	1	Absent
Rumen	0	Preserved motility
	1	Atony
	2	Tympany
	3	Ventral abdominal distension
Abdominal wall tension	0	Absent
	1	Present
Percussion and auscultation (PA)	0	Negative
	1	Positive on the right side with Steelband
	2	Positive on the left side with Steelband
Ballottement and auscultation (BA)	0	Negative
	1	Positive with non-metallic splashing on right and/or left
	2	Positive with metallic splashing on right and/or left
Fecal consistency	0	Normal
	1	Decreased consistency
	2	Increased consistency

Table 3 - Clinical examination findings categorized according to a standardized scoring system based on the framework described by Pugh and Baird (2011) [9]. Each parameter was assigned a score reflecting increasing severity or deviation from normal physiology. The table reports the frequency and percentage of each clinical finding, stratified by survival outcome (survived vs. deceased).

Parameter	Category	Score	Survived	Deceased	Total (n)
Posture	Standing	0	6 (100.0%)	6 (66.66%)	12 (80.0%)
	Sternal recumbency	1	0 (0.0%)	3 (33.33%)	3 (20.0%)
Behavior	Alert	0	5 (83.33%)	2 (22.22%)	7 (46.66%)
	Depressed mental status	1	1 (16.66%)	4 (44.44%)	5 (33.33%)
	Comatose state	2	0 (0.0%)	3 (33.33%)	3 (20.0%)
Nutritional status	Normal weight	0	4 (66.66%)	7 (77.77%)	11 (73.33%)
	Cachectic	1	1 (16.66%)	2 (22.22%)	3 (20.0%)
	Obese	2	1 (16.66%)	0 (0.0%)	1 (6.66%)
Hydration status	Normally hydrated	0	6 (100.0%)	6 (66.66%)	12 (80.0%)
	Dehydrated	1	0 (0.0%)	3 (33.33%)	3 (20.0%)
Thoracic auscultation	Normal thoracic auscultation	0	6 (100.0%)	9 (100.0%)	15 (100.0%)
Episcleral vessels	Not injected episcleral vessels	0	6 (100.0%)	5 (55.55%)	11 (73.33%)
	Injected episcleral vessels	1	0 (0.0%)	4 (44.44%)	4 (26.66%)
Mucous membranes	Pink mucous membranes	0	6 (100.0%)	5 (55.55%)	11 (73.33%)
	Pale mucous membranes	1	0 (0.0%)	4 (44.44%)	4 (26.66%)
Veins	Normally filled veins	0	6 (100.0%)	6 (66.66%)	12 (80.0%)
	Collapsed veins	1	0 (0.0%)	3 (33.33%)	3 (20.0%)
Nervous system and sensory organs	Comatose state (no reflex)	1	0 (0.0%)	3 (33.33%)	3 (20.0%)
	Opisthotonus	2	1 (16.66%)	1 (11.11%)	2 (13.33%)
	Ataxia	3	1 (16.66%)	1 (11.11%)	2 (13.33%)
	Nystagmus	4	1 (16.66%)	4 (44.44%)	5 (33.33%)
Appetite	Good appetite	0	4 (66.66%)	3 (33.33%)	7 (46.66%)
	Absent appetite	1	2 (33.33%)	6 (66.66%)	8 (53.33%)
Rumen	Preserved rumen motility	0	2 (33.33%)	1 (11.11%)	3 (20.0%)
	Rumen atony	1	3 (50.0%)	8 (88.88%)	11 (73.33%)
	Tympany	2	1 (16.66%)	2 (22.22%)	3 (20.0%)
	Ventral abdominal distension	3	0 (0.0%)	4 (44.44%)	4 (26.66%)
Abdominal wall tension	Compliant abdominal wall	0	6 (100.0%)	3 (33.33%)	9 (60.0%)
	Tense abdominal wall	1	0 (0.0%)	6 (66.66%)	6 (40.0%)
Percussion and auscultation (PA)	Negative (PA)	0	5 (83.33%)	7 (77.77%)	12 (80.0%)
	Hyperresonance (PA)	1	1 (16.66%)	2 (22.22%)	3 (20.0%)
Ballottement and auscultation (BA)	Negative (BA)	0	4 (66.66%)	7 (77.77%)	11 (73.33%)
	Non-metallic splashing both sides (BA)	1	2 (33.33%)	0 (0.0%)	2 (13.33%)
	Metallic splashing left (BA)	2	0 (0.0%)	2 (22.22%)	2 (13.33%)
Fecal consistency	Normal fecal consistency	0	4 (66.66%)	6 (66.66%)	10 (66.66%)
	Decreased fecal consistency	1	2 (33.33%)	3 (33.33%)	5 (33.33%)

Auscultation of the thorax revealed no abnormal findings in any of the patients (score 0). Episcleral vessel injection (score 1) was observed in 4 animals (26.66%), all of which were non-survivors ($p = 0.067$). Pale mucous membranes (score 1) were also found only among non-survivors ($p = 0.076$). In contrast, pink mucous membranes (score 0) were noted in 73.33% of cases.

Collapsed veins (score 1) were observed only in non-survivors ($p = 0.059$), while all survivors had normally filled veins (score 0). Neurological signs were reported in a subset of animals. Two patients (13.33%) showed opisthotonus (score 2), one of whom died ($p = 0.756$). Ataxia (score 3) was observed in two cases (13.33%) as well, with one patient surviving ($p = 0.756$). Nystagmus (score 4) was present in five animals (33.33%), four of whom died ($p = 0.084$). Appetite was absent (score 1) in 53.33% of cases and present (score 0) in the remaining 46.66%. Among the non-survivors, anorexia was present in 66.66%, while 66.66% of the survivors showed preserved appetite ($p = 0.173$).

Rumen assessment revealed that 80% of the animals presented one or more pathological signs. Atony (score 1) was the most frequent finding (73.33%), followed by tympany (score 2) and abdominal distension (score 3). Preserved motility (score 0) was noted only in 3 animals (20%), including one non-survivor ($p = 0.081$). Tension of the abdominal wall (score 1) was present in 40% of animals, all of which later died, while all discharged animals had a compliant abdomen (score 0) ($p = 0.054$).

Percussion and auscultation (PA) yielded hyperresonance (score 1) in 3 animals (20%), while 80% were classified as negative (score 0) ($p = 0.500$). Ballottement and auscultation (BA) showed metallic splashing (score 2) in 2 animals (13.33%), and non-metallic splashing (score 1) in another 2. The majority (73.33%) were negative ($p = 0.330$). Fecal consistency was normal (score 0) in 66.66% of animals, while 33.33% showed de-

Table 4 - Descriptive statistics (median, 25th and 75th percentiles) of clinical and blood gas parameters for the overall sample, survivors, and deceased animals.

Parameter	Total - Median (25th-75th)	Survivors - Median (25th-75th)	Deceased - Median (25th-75th)
Age (months)	60.00 (24.00-108.00)	42.00 (19.25-75.00)	72.00 (17.50-120.00)
RR (breaths/min)	24.00 (16.00-50.00)	35.00 (18.25-46.50)	20.00 (13.00-50.00)
HR (bpm)	112.00 (78.00-140.00)	120.00 (109.00-130.00)	96.00 (66.00-140.00)
Temperature (°C)	37.90 (36.50-39.40)	39.40 (38.00-39.63)	36.60 (33.70-38.20)
pH	7.42 (7.32-7.49)	7.37 (7.32-7.36)	7.45 (7.29-7.49)
PCO_2 (mmHg)	41.20 (32.10-54.60)	32.10 (18.90-30.30)	45.30 (33.13-53.78)
HCO_3^- (mmol/L)	25.40 (18.90-41.90)	18.90 (9.40-16.95)	26.00 (22.28-41.18)
Na^+ (mmol/L)	144.00 (141.00-148.00)	142.00 (131.00-137.00)	145.00 (141.75-151.00)
K^+ (mmol/L)	3.10 (2.50-4.00)	2.50 (2.30-2.45)	3.30 (2.65-4.23)
Cl^- (mmol/L)	108.00 (96.00-111.00)	100.00 (93.00-97.00)	109.00 (96.25-110.75)
Hct (%)	33.00 (26.00-36.00)	35.00 (35.00-35.00)	28.50 (23.75-36.00)
Glucose (mmol/L)	6.83 (1.20-11.30)	15.44 (7.00-12.72)	5.50 (1.05-8.98)
Lactate (mmol/L)	6.00 (0.92-14.00)	6.00 (1.44-5.50)	6.15 (0.76-14.34)

creased consistency (score 1). No cases of increased fecal consistency (score 2) were recorded ($p = 1.000$).

Body temperature revealed varying degrees of hypothermia in 9 animals, 7 of which subsequently died, whereas 6 animals were normothermic, of which 4 were later discharged. This difference was found to be statistically significant ($p = 0.018$). The continuous variables and laboratory findings are summarized in Table 4.

Blood gas analysis revealed findings consistent with metabolic acidosis in 3 out of the 11 animals assessed (27.27%). Of these, one case was compensated, while in the remaining two cases no compensation was observed, despite an attempt to lower pCO_2 values. One patient (9.09%) showed uncompensated respiratory acidosis. Metabolic alkalosis was observed in 4 animals (36.36%), of which 3 were compensated and 1 was uncompensated, as the pH remained above the reference range (7.35-7.50) despite elevated bicarbonate (HCO_3^-) levels. Overall, 8 out of 11 patients (72.72%) who underwent the analysis presented with an acid-base imbalance. No statistical differences were underlined between survived and deceased cases for these parameters ($p > 0.05$). Regarding electrolyte disturbances, the most frequent alterations involved potassium (K^+), which was below the reference range (3.90-4.40 mmol/L) in 7 animals (63.63%), and chloride (Cl^-), with 5 patients (45.45%) showing hyperchloremia and 2 patients (18.18%) presenting with hypochloremia (reference range: 95.00-103.00 mmol/L). Hyperlactatemia (reference range: 1.00-1.33 mmol/L) was observed in 7 out of the 11 animals evaluated. Also, for electrolyte and lactatemia, no statistical differences were underlined between survived and deceased cases ($p > 0.05$).

The difference in median blood glucose distribution between surviving and deceased animals was statistically significant (p value = 0.048). Among the animals that underwent blood gas analysis, hypoglycemia (reference range: 2.78-4.44 mmol/L) was detected in 3 out of 11 cases (27.27%), all of which subsequently died.

Rumen siphonage was performed in 6 out of 15 patients (40%). The primary purpose of this procedure was to relieve ruminal tympany and forestomach distension, which were present in all patients undergoing the intervention. In 2 cases (13.33%), ruminal decompression was unsuccessful due to the presence of thick, pasty material obstructing the tube. In 2 animals (13.33%), pH analysis of the ruminal fluid revealed either alkalosis or acidosis, and the introduction of the tube allowed for the endoruminal administration of pharmacological therapy to correct these abnormalities. In 1 patient (6.66%), the redox potential of the ruminal fluid was assessed using the methylene blue reduction test and was found to be null. In 3 cases (20%), the procedure also had diagnostic utility for ruminal foreign body syndrome, as plastic ties were retrieved incidentally upon tube removal. In 2 of these 3 cases (13.33%), the procedure was both diagnostic and therapeutic, allowing for the removal of the ruminal foreign body.

Imaging

Radiographic examination was performed in 7 out of 15 patients (46.66%). The findings were similar across all animals in which imaging was conducted (Figure 1 and 2): moderate to severe distension of the forestomaches were observed, along with the presence of fluid and gas within the organ lumens. Foreign bodies were identified as formations of variable size, often with mineral density, heterogeneously radiopaque, irregular in shape, sometimes with well-defined margins, and in other cases less distinct due to the presence of finely granular material. In all animals that underwent radiographic imaging, this diagnostic tool proved conclusive for the definitive diagnosis of ruminal foreign body.

Ultrasonographic examination was performed in 2 out of 15 patients (13.33%). In both cases, the purpose of the investigation was to confirm the suspected presence of a foreign body in the forestomaches. In one patient, the clinical examination suggested the presence of a mass with increased consistency in the area of the left flank: ultrasonography revealed increased gas content appearing as multiple comet-tail artifacts and enabled localization of the mass within the gastrointestinal tract, although it did not allow precise identification. In the second case, ul-

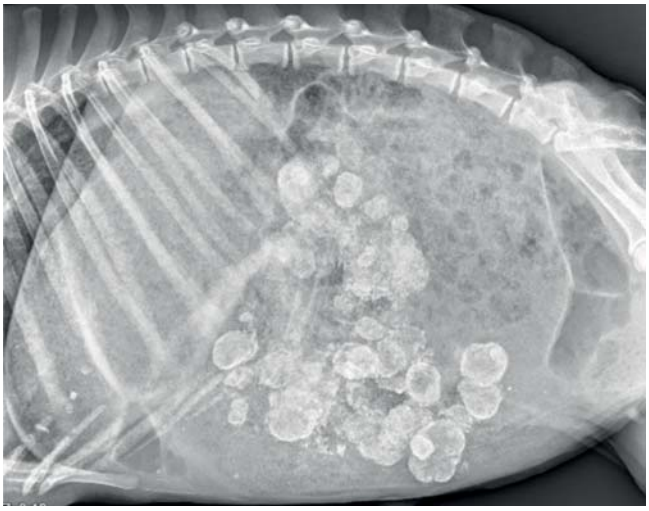

Figure 1 -Right lateral abdominal radiograph of goat. Severe distension of the forestomach is evident, with the presence of fluid and gas within the gastrointestinal lumen. Multiple foreign bodies were visible as irregularly shaped, heterogeneously radiopaque structures of varying sizes, with mineral density. Some of these foreign bodies show well-defined margins, while others appear less distinct due to the presence of finely granular material.

Figure 2 -Ventrodorsal abdominal radiograph of a goat. A foreign body is visible as an irregularly shaped, heterogeneously radiopaque structure with mineral density.

trasonography was performed following rumen siphonage, which had led to the retrieval of plastic material from the ruminal lumen. The aim was to assess the presence of residual foreign material and support the suspicion of a pyloric obstruction caused by the foreign body. However, this diagnostic method did not lead to a definitive diagnosis.

Following the definitive diagnosis of ruminal foreign body syndrome, surgical treatment via rumenotomy was performed in 5 out of 15 patients (33.33%). Adequate stabilization of the patient's general condition through targeted fluid therapy was essential before proceeding with surgery. Once the animals were clinically stable, surgical intervention could be undertaken. In all treated cases, the surgical procedure successfully allowed the removal of the foreign material present in the gastrointestinal compartment. Of these animals, 2 (40%) were discharged and returned home, while the remaining 3 (60%) died due to severe impairment of ruminal function and overall health condition.

Necropsy was performed in 5 out of the 9 deceased patients (55.55%). In all examined animals, marked distension of the forestomaches were observed, with the presence of frothy bloat. In 2 of the 5 cases, foreign bodies were found to be obstructing the cardia, preventing proper feeding and rumination. In another 2 animals, the foreign bodies were lodged at the reticulo-omasal orifice, thereby impeding the normal passage of ingesta through the forestomaches and resulting in ruminal stasis. Histopathological findings included, in 2 out of 5 cases, numerous multifocal confluent hyperemic areas of the ruminal mucosa, associated with severe and diffuse mucosal autolysis. In one case, multiple focally extensive mucosal ulcers were identified, characterized by necrotic debris and a marked inflammatory infiltrate within the lamina propria. In all animals that underwent necropsy, the presence of a ruminal foreign body had been only a suspected differential diagnosis during life; postmortem examination allowed definitive identification of the foreign material and confirmation of the diagnosis. Through the diagnostic process conducted either intra vitam or via postmortem necropsy, the exact nature of the foreign bodies present within the gastrointestinal tract was determined in all 15 patients included in the study (Figure 3). In 12 animals (80%), the foreign material consisted of plastic objects such as plastic bags, hay bale twine, or plastic netting. In 2 cases (13.33%), the foreign body was consistent with a bezoar. Finally, in 1 case (6.66%), multiple coalescing, rounded foreign bodies were identified, resembling knotted rope.

DISCUSSION

Ruminal foreign body syndrome is a condition that can occur in all domestic ruminants, triggered by the accidental or voluntary ingestion of inedible materials. The foreign body typically lodges in the forestomach, leading to local and systemic consequences with a nonspecific clinical presentation ranging from mild to severe, potentially resulting in the animal's death [2, 10]. In the present study, the prevalence of ruminal foreign bodies was 4.31% of all small ruminants admitted from September 2016 to March 2022 at the University of Milan. Literature reports interesting data on the prevalence of this syndrome in regions where environmental pollution significantly contributes to its incidence. For example, a study conducted in Ethiopia-where plastic waste management is lacking-reported that among 500 ruminants (240 sheep, 60 goats, 200 cattle), 109 (21.8%) had one or more indigestible foreign bodies in their rumen or reticulum. Prevalence was 29.6% in sheep and 16.7% in goats [10]. Other authors suggest that sheep and goats may be less susceptible to this condition due to their inherent selectivity in feed intake compared to cattle [11]. The prevalence observed in our study is lower than that reported in the literature; however, the authors in previous studies primarily analysed livestock raised in extensive farming systems, whereas our research focused exclusively on companion animals. A particularly notable finding was that all the patients in this study were companion animals and none were farm animals. These animals were often kept loose in domestic environments, some-

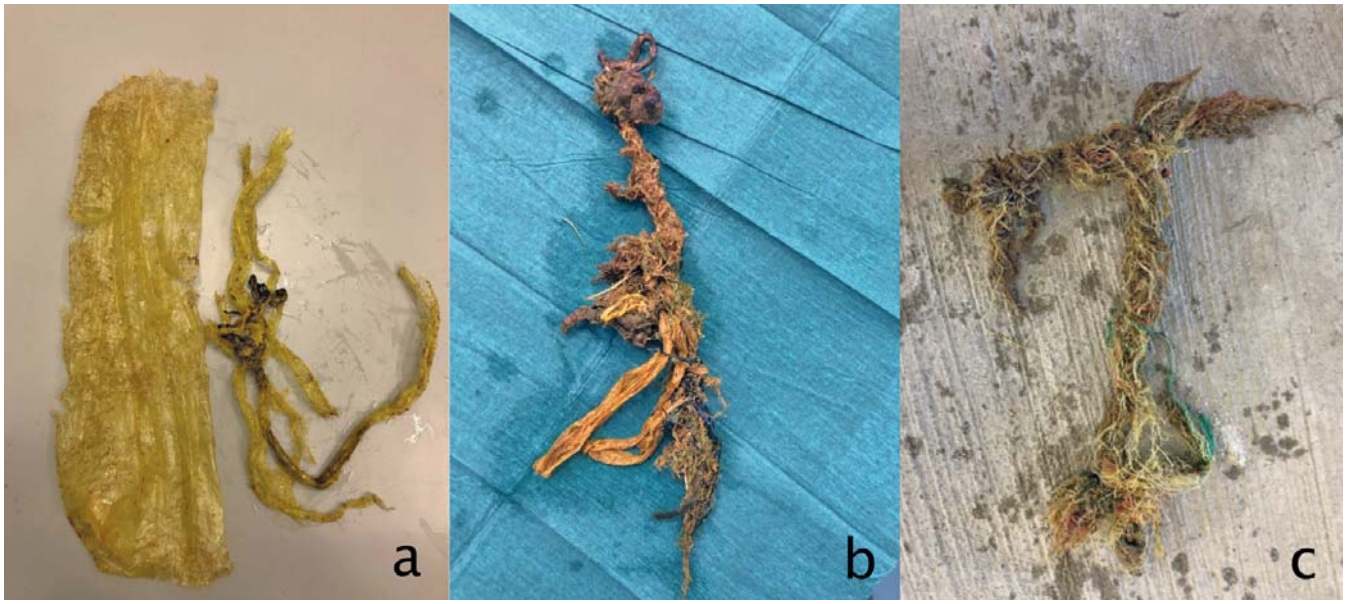

Figure 3 -Examples of foreign bodies removed from the gastroenteric tract in small ruminants affected by ruminal foreign body syndrome. a: Plastic bags and multiple ribbon-like plastic fragments recovered during post-mortem examination; b: Conglomerate of plastic cords mixed with feed material removed during rumenotomy; c: Compacted bundle of plastic cords removed during rumenotomy.

times cohabiting with other species. This situation may reflect poor owner control over the animals' diet and living conditions. Analysis of year-by-year data also showed an increase in the number of hospitalized small ruminants over time, indicating that the Veterinary Teaching Hospital of University of Milan has become a reference centre not only for livestock but also for companion ruminants.

Multiple studies have identified environmental pollution and management type as predisposing factors for ruminal foreign body syndrome. Animals allowed to roam freely in urban or suburban areas, or pastured without close supervision, are at increased risk of ingesting foreign materials. This emphasizes the critical importance of dietary control in the prevention of this condition [12]. Additionally, literature indicates that adult animals are more frequently affected than young ones [13], a finding consistent with our data: 11 (73.33%) out of 15 animals were adults (> 24 months), while 4 (26.66%) were juveniles (< 24 months).

History reported by owners at admission, including sensorium depression, abdominal distension, and weight loss, were easily correlated with the physical exam findings upon admission. The clinical examination revealed common alterations in the nervous system and sensory organs, appetite, and ruminal motility. These findings are in line with literature that reports abdominal distension, anorexia, decreased feed intake, and prolonged recumbency as typical signs of ruminal foreign body syndrome [7, 12, 14, 15]. Another relevant finding from our results was that all animals had a history of ingesting large amounts of fermentable carbohydrates presented with abdominal distension. Factors contributing to this included the foreign body's mechanical obstruction, ruminal hypomotility or atony, and inappropriate diets high in fermentable carbohydrates and low in fiber, all predisposing to acute gaseous or frothy bloat, which clinically manifests as marked left-sided abdominal distension [16, 17].

Another common finding in our sample was inappetence and weight loss; decreased feed intake reduces the availability of volatile fatty acids in the rumen, which ultimately decreases energy availability and results in lethargy, recumbency, and sensorium depression. Furthermore, foreign bodies may obstruct normal ingesta flow [14, 18].

These nonspecific signs highlight the need for complementary diagnostics to reach a definitive diagnosis [19].

Blood gas analysis revealed acid-base imbalances in 8 of the 11 patients tested (72.72%) and electrolyte imbalances, particularly hypokalemia in 7/11 cases (63.63%). The explanation of hypokalemia could be a decreased feed intake [16]. In addition, elevated lactate levels were found in 7/11 patients (63.63%), likely due to excessive lactic acid production by altered ruminal microbiota, leading to gastrointestinal disorders, anorexia and probably hyperlactatemia was the cause of acid-base imbalance. High-energy, low-fiber diets reduce salivation and buffering capacity, fostering acid/base imbalance and promoting growth of lactic acid-producing bacteria intake [16].

Blood glucose analysis indicated hypoglycemia in 3 of the 11 animals tested (27.27%), all of whom died. While overall prevalence was low, hypoglycemia was significantly associated with mortality, indicating poor prognosis. Hypoglycemia is often related to malnutrition and negative energy balance, as observed in all three cases, which also exhibited severe neurological signs and hypothermia. Literature describes similar clinical signs in calves with severe hypoglycemia, including opisthotonos, lethargy, coma, and seizures [20]. Body temperature was also significantly lower in non-survivors compared to survivors.

Radiographic imaging, performed in 7 animals (46.46%), was essential for achieving a definitive diagnosis. Although few studies address radiographic diagnosis of ruminal foreign bodies in small ruminants, available data from other species support its efficacy in identifying and localizing foreign material [21]. In contrast, ultrasonography-while a gold standard in many species-was not diagnostic in our cases due to the gas-filled nature of the forestomaches, which limits ultrasound evaluation. However, ultrasonography was helpful in identifying excessive gas and, in some cases, ruminal wall thinning, a finding described in histopathological studies due to chronic mechanical trauma from the foreign body [22; 23].

Treatment for ruminal foreign body syndrome involves initial stabilization with supportive therapy (fluids and vitamins), followed by surgical removal. In all cases where rumenotomy was performed, the procedure successfully removed the foreign body, consistent with literature describing rumenotomy as an effective therapeutic intervention [24]. Interestingly, 5 of the 15 patients also had concurrent diagnoses of indigestion and polyencephalomalacia, a condition caused by secondary thiamine deficiency. This disease is associated with increased intracranial pressure, cortical necrosis, blindness, sensorium depression, and motor dysfunction. Disruption of ruminal fermentation impairs thiamine availability. Factors such as sudden dietary changes and diets high in fermentable carbohydrates contribute to this imbalance [16]. In our study, most patients had a history of abnormal neurologic signs and diets rich in fermentable carbohydrates.

Post-mortem examinations were performed in 5 of the 9 deceased animals (55.55%). In four of these, the foreign body was found to be obstructing the cardia or the reticulo-omasal orifice, preventing eructation or normal ingesta flow. Another common necropsy finding was ruminal overdistension, often with frothy bloat. The larger volumes of foreign material were reported to impact ruminal function [15, 25]. Histopathological findings included multifocal hyperemia, diffuse mucosal autolysis, focal ulcers with necrotic debris, and dense inflammatory infiltrates-changes consistent with traumatic injury from the foreign body. These histological alterations resemble those seen in chronic ruminal acidosis as reported in literature [13].

Foreign body type varies with housing, diet, species cohabitation, and feed storage. In our study, the most common material was plastic (80%), consistent with other studies reporting plastics (79.2%), clothing (15.3%), and ropes (12.3%) as the main types of ingested foreign material. As reported in literature, type of foreign body was correlated with different way to keep these new pets [26].

CONCLUSIONS

This study highlights the diagnostic challenge of ruminal foreign body syndrome in small ruminants, due to nonspecific clinical and laboratory signs. It should be suspected in animals with neurologic signs and abdominal distension. Blood gas and serum glucose analyses are key for diagnosis and prognosis, guiding supportive therapy. Radiography is recommended, while ultrasonography is less useful due to ruminal gas. Supportive care should include vitamin B1 to prevent polyencephalomalacia. Once stabilized, surgical removal is advised to resolve associated metabolic imbalances.

Ethical Approval

Not applicable. The present study is based on a retrospective analysis of clinical cases and did not involve any experimental procedures on live animals. All animal owners signed an informed consent for the procedures performed and authorized the use of clinical data for research purposes.

Author Contributions

Conceptualization: Davide Pravettoni, Antonio Boccardo, Giulia Sala; Data Collection: Francesca Crosta, Vincenzo Ferrulli, Elisa Gazzola, Linda Ucci, Donatella De Zani; Data Analysis: Giulia Sala; Manuscript Writing: Giulia Sala, Elisa Gazzola, Linda Ucci; All authors have read and approved the final manuscript.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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