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The Digestive System of New World Camelids — Common Digestive Diseases of Llamas

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Introduction

Llamas (*Lama glama*) belong to a group of animals called South American or New World Camelids, which also includes the Guanaco (*Lama guanicoe*), the Vicuna (*Lama vicugna*) and the Alpaca (*Lama pacos*). They are originally from South America, residing in the Andes mountains.

These animals are of special interest because their digestive system is significantly different from that of the typical ruminants allowing them to have a higher digestibility coefficient, even higher than the sheep (25% more).¹ They are both browsers and grazers, and will consume a variety of plants including herbs, lichen and bark as well as grasses. Of the New World Camelids, Llamas and Alpacas have gained more popularity in the U.S. because of their packing abilities and wool quality. More and more Llama owners require the services of veterinarians to treat and prevent common diseases.

To provide adequate professional services to Llama owners, veterinarians should be aware of the differences between the digestive system of the New World and typical ruminants. The purpose of this study is to present in a practical fashion the anatomy and physiology of the Llama's stomach and to review the different pathological conditions and digestive diseases reported in New World Camelids.

Anatomy of the Llama's Digestive System

Oral Cavity

Llamas have a cleft upper lip which allows for very efficient prehension abilities. A wrap around,

stripping mechanism characterizes their grazing and browsing behavior, and they are able to nip forage by virtue of a toothless upper dental pad.²

Their dental formula is I 1/3, C 1/1, PM 2-3/1-2 (Deciduous) and I 1/3, C 1/1, PM 1-2/1-2, M 3/3 (Permanent). The upper incisor migrated caudally in the jaw and became the caniniform or fighting tooth. These look like upper canines and are usually removed in males to facilitate handling and assure safety.³ The esophagus can be up to four feet long in adult animals and connects to the first compartment of the stomach.

Stomach

There has been much controversy as to how to classify the stomach of New World Ruminants. For this reason most of the research studies concentrate on the normal anatomic and physiologic aspect rather than the pathology of the Llama stomach. It seems though that recent studies agree on the three compartment classification.^{2,4}

The first compartment comprises 83% of the total stomach volume and is analogous to the rumen. It is further divided into the cranial and caudal sac by a transverse muscular pillar.^{4,5} A small part of the mucosa of this compartment is lined by stratified squamous epithelium and the remainder by glandular epithelium with secretory saccules that have the capability to evert during the process of digestion. A ventricular groove similar to the one present in the advanced ruminants is also present in the first compartment. During the neonatal period it allows fluid ingesta to bypass the first and second compartments and go into the third.

The second compartment is analogous to the reticulum, and contains 6% of the total gastric volume. The mucosal surface exhibits a retiform pattern composed of absorptive cells and mucous

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glands. The glandular mucosa is papillated and the cells are coated with mucus. The lower curvature is lined by stratified squamous epithelium. In contrast with the typical ruminant's reticulum, the second compartment is in a dextrocaudal position and distinctly separated from the first compartment. Through a tubular passage, it connects to the third compartment.⁵

The third compartment is the abomasum counterpart of the Llama's stomach. It is composed of entirely glandular mucosa and is structurally divided into fifths; the first 4/5 containing mucosal glands and the last 1/5 containing true gastric and pyloric glands. There are no rugae present, but a pyloric sphincter demarcates the transition into the ampulla of the duodenum.^{2,3,5}

Physiology of the Llama Stomach

The physiological function of the Llama's stomach is still a source of scientific research. The characteristic glandular content of the three gastric compartments is probably responsible for the high digestibility coefficient these animals possess. A few aspects about secretion, absorption and motility are worth mentioning.

Secretion

The glandular sacculi of the three compartments secrete significant amounts of bicarbonate. In association with this, a reciprocal uptake of chloride from the lumen occurs.^{6,7} This increases efficient buffering of volatile fatty acids, allowing for better absorption and digestion of cellulose. The absorption of fatty acids is 2 to 3 times faster than in true ruminants. A thin fluid layer of mucus is present at the surface. This maintains a lower pH than the rest of the bulk solution and contributes to better absorption.^{7,8} In addition, Llamas are able to secrete urea from the blood into the rumen for protein synthesis. This "reutilization" mechanism accounts for their survival on low protein diets.²

Motility

The process of digestion in Llamas is subdivided into prehension, mastication, salivation, swallowing, enzymatic digestion, mixing, microbial digestion, eructation, regurgitation, remastication, re-swallowing and digestion. The motility pattern, however, varies, resulting in a continuous pattern

with faster mixing of ingesta. There are rhythmic contractions of the first and second compartment followed by eructation and regurgitation in a sequence of four to five contractions per minute.⁹ Vagal innervation seems to also control contractions as in true ruminants since vagal blockade will stop all contractions in compartments one and two.¹⁰ In general, the differences in motility are related to sequence and number of contractions, allowing for a very efficient exchange of digesta within the glandular region and providing the Llama with maximum efficiency to digest the poor roughage diets naturally found in the Andes mountains.

Abdominal Diseases

Dr. Fowler described the group of digestive disorders commonly found in Llamas as the "acute abdomen syndrome".³ Clinical signs include anorexia, depression, abdominal distension, normal to subnormal temperature, increased pulse and respiration and colic signs similar to horses. These signs are not diagnostic, therefore other tests should be performed. Diagnostic procedures should include abdominocentesis, hemogram, pH of stomach contents and auscultation. Differentials include perforation of gastric ulcers, strangulation of intestinal loops, obstruction caused by intussusception or torsion in the small intestines, and impaction. More common are conditions such as constipation and indigestion, in which adequate treatment as well as diet modification is recommended.¹¹ In younger animals or neonates, bladder rupture, clostridial enterotoxemias and retained meconium should be considered as well. Conditions such as bloat - hyperacidity from grain overload, abomasal displacement and traumatic reticuloperitonitis or hardware disease are not common in Llamas. This is due to an increase in the feeding of concentrate diets too rich in protein.

Treatment Regimen

The treatment for abdominal diseases in Llamas is similar to that in domestic ruminants. When signs of an acute abdomen are present, it should be considered an emergency requiring immediate care.

Banamine at 1.1 mg/kg IM SID is given to control pain and Cimetidine at 5 mg/kg TID when ulceration is suspected. Transplantation of stomach contents from another Llama or from a sheep or cow can be helpful, especially in cases of atony/indigestion. Use of a commercial concentrate of

Lactobacillus formulation has also been used. If dehydration or shock is present, parenteral fluids by a jugular catheter can be useful.^{2,3,11} Impaction, rumenitis, and debilitated animals (especially neonates)¹³ may benefit from medication given via stomach tube. Finally, use of mineral oil, bicarbonate and vinegar can help when atony related to grain overload is suspected.¹¹

Preventative Measures

It is recommended that Llamas be kept on mostly mixed grasses and legume pastures. Concentrate supplementation should be given if the energy requirements are high, as in packing and pregnant/lactating Llamas. A vaccination program is available for the enterotoxemias caused by *Clostridium perfringens* type C and D. The dam is vaccinated two months prepartum and the neonate is vaccinated at one month, then again at two months of age. These are followed by annual boosters thereafter.

Enteritides

Although cases of infectious enteritis have not been documented very often, there is clinical evidence of the Llama's susceptibility to some of the common enteric pathogens. As mentioned before, neonates are susceptible to clostridial enteritis and proper vaccination will help in preventing losses. Colibacillosis has been reported in Guanacos and coccidial enteritis has been discovered in zoo Llama specimens.¹⁴ Other agents such as Salmonella, corona virus, and rota virus may be involved in causing enteritis in Llamas.

Gastrointestinal Parasitism

Those parasites that commonly affect cattle and sheep have been found in South American Camelids.³ Not all of these organisms will cause clinical signs but can definitely be a burden and decrease the animal's performance. Clinical signs such as chronic weight loss, sporadic anorexia, and diarrhea could indicate that heavy parasitism is the primary disease. Treatment includes the use of deworming products that are used for cattle and sheep but not approved for Llamas.¹² These are Ivermectin - .2 mg/kg, Fenbendazole - 10.0 mg/kg, Levamisole - 5-8.0 mg/kg, and Mebendazole - 10-20.0 mg/kg.

An early worming program, followed by regular fecal evaluations forms a good control plan.

New animals coming into a herd should be isolated and tested first.

Miscellaneous Diseases

The following are conditions that have been commonly reported in Llamas raised in the United States:

- Tooth abscessation and dental malocclusion
- Choke
- Enteroliths (prized by the Incas as having medicinal properties)
- Leptospirosis has been reported in Guanaco.¹⁴ Signs were non-specific and included recumbency, expiratory dyspnea and abdominal pain.
- Traumatic reticuloperitonitis although extremely rare in Llamas, has been reported.¹¹

A Few Facts About Llama Nutrition

Generally Llamas, Guanacos and Alpacas are grazers and browsers. They can subsist in forages that contain 5-6% protein. A diet too high in protein leads to complications such as the acute abdomen syndrome. Dr. Johnson recommends a mixed pasture (grass and legume, avoiding straight alfalfa). Alfalfa as hay is a good choice.^{2,3}

An adult Llama consumes about 2% of its body weight per day, increasing to 3% with activity, and to 4% if lactating or pregnant. Supplementation of their diet with concentrates or grain is still questionable but justifiable if they are going to be utilized as packing animals.

Vitamin E and selenium deficiency has been reported in Llamas. Supplementation should be that used for cattle and sheep: Newborns - .25-1.0 mg/animal, Juveniles - 1-3 mg/animal, and Adults - 5-10 mg/animal.

Two Cases Presented at Iowa State University Veterinary Teaching Hospital

Signalment

Nine day old male Guanaco

- Weak and had to be tube fed using the mother's milk and supplement
- Lost the hair around the eyes, dehydrated and uncoordinated
- Temperature of 104° F for three days
- Defecation and urination normal

Physical Exam

- Depressed, lacking coordination in its movement (legs and neck)
- 6% dehydrated
- Body temperature was still 104° F.
- Diarrhea

Plan

CBC and Panel, including globulins profile, skin scraping and culture of periorbital area.

Results

Hb - 13.1	Plasma Protein - 4.4
PCV - 30	Fibrinogen - 300
WBC - 11,200	BUN - 24
Bands - 336	Glucose - 192
Segs - 8288	SGOT - 73
Lymphocytes - 2576	SDH -3

Electrophoresis - 80 mg/100 ml of globulins characteristic of agammaglobulinemia.

At this point the first differential diagnosis was failure of passive transfer with other complications such as septicemia. The Guanaco deteriorated despite aggressive therapy with intravenous fluids, antibiotics and tube feeding of milk and supplement. On October 3rd of 1985 it died and a post mortem examination was requested. Necropsy confirmed a diagnosis of acute fibrinopurulent bronchopneumonia and severe acute enteritis (colibacillosis from cultures of the small intestines).

Signalment

- A 3 year old female Llama
- Difficult respiration
 - Lethargy, anorexia and depression
 - Diarrhea

Physical Exam

- A grade II systolic murmur
- A diphtheritic membrane on the oral mucosa
- Halitosis
- Retained deciduous teeth

At this point, the differentials were parasitism, *Fusobacterium* infection, *Salmonella* enteritis, septicemia and renal disease.

Plan

CBC, Panel, treat with Banamine; 1 ml IM, Penicillin; 7 ml IM and serology for BVD-BT.

Results

Hb - 9.1	Lymphocytes - 780
PCV - 20	Monocytes - 676
WBC - 2600	23 NRBC/100 RBC
Bands - 468	Plasma Protein - 4.1
Segs - 676	Fibrinogen - 800
	Reticulocytes - 0%
	BUN - 36
	Creatinine - 1.30

A urinalysis was done. There was a 1+ proteinuria and a specific gravity of 1.029.

Fecal flotation yielded a mixed population of gastrointestinal nematodes;

Nematodirus helvetians and *Triclostrongylus colubriformis* - both potential serious pathogens in camelids.

Haemonchus

Cooperia

Trichuris

Eimeria.

Treatment consisted of supportive care, antibiotics and Banamine. The animal died 4 days later and a post mortem examination was requested.

On necropsy the following findings were reported:

- Emaciation
- Serous, straw color peritoneal fluid
- Marked serous atrophy of fat
- Pericardial fluid is serosanguineous
- Multiple oral ulcerations with pseudo-membranous material in the esophagus
- Fibrin tags were adhered to the serosal surface of the digestive tract organs, and the mucosa of the third compartment was eroded and ulcerated. A few nematodes were found in the intestinal lumen.

The final diagnosis was gastrointestinal nematodiasis. The owner was advised to improve his worming program of the herd. The owner also decided to test the herd for BVD, Bluetongue and Epizootic hemorrhagic disease all yielding negative results on Serology.

Conclusion

Llamas are progressively increasing in popularity in the United States. In some states such as California, Colorado and Montana, entire farms are concentrating their efforts in breeding and raising Llamas and Alpacas. They should no longer be considered an exotic species limited to zoo-

logical parks, but a new domestic animal that demands professional care. Although many similarities exist between the diseases that Llamas and cattle can get, there are significant variations that require treatment modifications.

New World Ruminants, having the advantage of a higher digestibility coefficient will continue to be the subject of further scientific research. I hope to see more veterinary involvement in these research projects to adequately expand our services.

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