Abomasal Emptying Defect in Sheep

**OVERVIEW**
Abomasal emptying defect (AED) is a syndrome of mature Suffolk sheep characterized by chronic progressive weight loss and abomasal dilatation in the absence of mechanical obstruction.

**INCIDENCE/PREVALENCE**
Unknown

**GEOGRAPHIC DISTRIBUTION**

**SYSTEMS AFFECTED**
Dietary

**PATHOPHYSIOLOGY**
- The pathogenic mechanism is unclear.
- Neurotoxicosis has been suggested.
- The syndrome shares some characteristics with chronic idiopathic intestinal pseudo-obstruction of humans. Affected individuals have clinical signs suggesting partial or complete gastric obstruction, when none is present.
- Morphologic investigations of human patients indicate degenerative changes in the smooth muscle or the tunica muscularis of the entire plexus.

**HISTORICAL FINDINGS**
- Condition occurs sporadically, typically affecting a single individual. Flock management is usually excellent despite affected individuals within it.
- Owners may report weight loss in affected animals despite providing extra nutrition, and anthelmintic treatment. Owners may note that the animal appears "bored" despite inappetence.

**PHYSICAL EXAMINATION FINDINGS**
- Body temperature is within normal limits unless concurrent disease is present. Heart and respiratory rates may be normal to increased. Fecal consistency usually normal, but volume often decreased.
- Abdominal conformation may be normal; bilateral, symmetrical abnormally distended may occur (distension of the left paralumbar fossa and right ventrolateral abdomen when the animal is viewed from behind); unilaterally distension may be present (right ventrolateral aspect of the abdomen).
- Rumen contractions are variable. Rumen hyperactivity can be dramatic in affected cattle and the left paralumbar fossa appears to be in constant motion, reflecting almost constant rumen activity.
- Sheep with AED are in varying stages of cachexia and their abomasal wall feels "thin" due to muscle wasting. Abdominal organs may also lack tone or give the impression of being fluid-filled. In some instances, the caudal border of the abomasum may be visible and palpable as it extends beyond the last rib on the ventrolateral aspect of the abdomen. The distended abomasum usually feels fluid filled rather than the doughy or firm consistency often associated with abomasal impaction in cattle.

**DIAGNOSIS**
**DIFFERENTIAL DIAGNOSES**
- Neoplasia.
- Malnutrition, dental problems, parasitism, including scrapie, Johne’s disease, lymphadenitis and other chronic infections.

**OTHER LABORATORY TESTS**
- Hematology and serum chemistry analysis are usually normal.
- Metabolic alkalosis with hypochloremia and hyperkalemia observed with proximal GI obstruction in cattle is not consistently noted with AED.
- Elevation in liver enzymes (AST, SDH, GGT) may be noted.
- Increased intra-abdominal pressure from a distended abomasum may lead to secondary liver congestion and ischemia and can precipitate leakage of hepatic enzymes.
- Urinalysis usually unremarkable.

**OTHER DIAGNOSTIC PROCEDURES**
- Abdominal ultrasoundography may be more useful than radiographic imaging. A 3 to 5 MHz linear or convex array can provide adequate images of the abomasum. When placed on the lower right abdomen, the normal abomasum will not extend beyond the last rib. In animals with AED the abomasum will usually appear 2 to 4 times normal size.

**PATHOLOGIC FINDINGS**
- Gross necropsy reveals a greatly distended abomasum and patent pylorus.
- Abomasal contents are usually liquid but may be dry. Histopathologic changes in the abomasum include smooth muscle degeneration, vacuolation, and varying degrees of necrosis. Degenerative changes have been reported in the celiacomesenteric ganglia.

**TREATMENT**
**SUGGESTED DRUGS**
- Metoclopramide (0.1 mg/kg, q8h, SQ) as an adjunct to the surgery. Concurrent fluid replacement and electrolyte correction therapy is critical to survival and success.

**MEDICATIONS**
- Metoclopramide (0.1 mg/kg, q8h, SQ) as an adjunct to abomasotomy has been reported to improve abomasal motility. This medication should not be used if GI obstruction is suggested.

**DIAGNOSTIC PROCEDURES**
- Abdominal ultrasonography may be more useful than radiographic imaging. A 3 to 5 MHz linear or convex array can provide adequate images of the abomasum. When placed on the lower right abdomen, the normal abomasum will not extend beyond the last rib. In animals with AED the abomasum will usually appear 2 to 4 times normal size.

**OTHER DIAGNOSTIC PROCEDURES**

**SURGICAL CONSIDERATIONS AND TECHNIQUES**
An abomasotomy is best performed under general anesthesia, although a local line block can be used. The animal is placed in left lateral recumbency and a right paracostal approach provides excellent access to the abomasum. Subsequently the abomasum is opened and its contents removed, and the organ is flushed and closed in a routine manner. Treatment with metoclopramide should be used as an adjunct to the surgery. Concurrent fluid replacement and electrolyte correction therapy is critical to survival and success.
Erythromycin (8.8 mg/kg, IM) increased abomasal emptying rate in dairy calves; pre-operative administration (10 mg/kg, IM) increased abomasal emptying after surgical correction of left displaced abomasum in dairy cows. Erythromycin may therefore provide some benefit in treatment of AED.

CONTRAINDICATIONS
Neostigmine should not be used in affected animals since it increases frequency rather than strength of rumen contractions.

PRECAUTIONS
Appropriate milk and meat withdrawal times apply to all compounds administered to food-producing animals.

POSSIBLE INTERACTIONS
N/A

FOLLOW-UP
EXPECTED COURSE AND PROGNOSIS
• The earlier that AED is recognized and treated, the better the prognosis; however, prognosis is guarded for long-term recovery regardless.
• In certain circumstances such as a ram completing a breeding season, or a late gestation ewe completing her pregnancy, a fair to good short-term prognosis may be offered if intensive treatment is provided early.

POSSIBLE COMPLICATIONS
• Complications related to abomasotomy: surgical dehiscence of the abomasal incision (especially if the abomasal wall has undergone degenerative changes) and dehiscence of the abdominal incision may occur (more likely in a debilitated patient).
• Once the condition is recognized, if treatment is declined, euthanasia should be offered as a humane resolution.

CLIENT EDUCATION
Owners of Suffolk sheep should be familiar with the breed predisposition for AED and educated regarding the clinical presentation.

PATIENT CARE
If intensive therapy is undertaken, the animal should be observed for attitude, appetite, fecal production, and abdominal conformation. Signs of improvement following abomasotomy and during metoclopramide therapy may include improvement in attitude and appetite, increased fecal production and decreased abdominal distention.

PREVENTION
Because the underlying cause and heritability of AED is unknown, recommendations cannot be made.

MISCELLANEOUS
ASSOCIATED CONDITIONS
Other concurrent conditions may occur with AED. Pneumonia and other organ failure can be secondary to any chronic debilitating disease.

AGE-RELATED FACTORS
AED usually occurs in mature sheep.

ZOOLOGIC POTENTIAL
N/A

PREGNANCY
In spite of treatment, pregnant animals may abort. Pregnant animals (especially mid- to late-term) represent an increased surgical risk.

BIOSECURITY
N/A

PRODUCTION MANAGEMENT
AED is usually observed in a single animal from a well-managed flock.

SYNONYMS
• Abomasal dilatation and emptying defect
• Abomasal impaction

ABBREVIATIONS
• AED = abomasal emptying defect
• AST = aspartate transaminase
• GGT = gamma-glutamyltransferase
• SDH = sorbitol dehydrogenase

SEE ALSO
Abomasal Impaction

Suggested Reading

Author Dennis D. French
Consulting Editor Erica C. McKenzie

Acknowledgement The author and book editors acknowledge the prior contribution of Michelle Kopcha.
Abomasal impaction occurs when there is obstruction to the passage of fluid and ingesta from the abomasum through the pylorus for feed, sand, gravel or other foreign bodies, or as a result of neurologic dysfunction from various conditions.

**CAUSES AND RISK FACTORS**

- Physical obstruction of outflow from the abomasum can occur when there is packing of straw or other low-quality roughages, or sand or gravel in the abomasum.
- Damage to branches of the vagus nerve as a result of traumatic reticuloperitonitis, lymphoma or other disorders can decrease the ability of the abomasum to empty.
- Failure of fluid to move from the abomasum into the intestines results in dehydration and starvation.
- Sequestration of hydrochloric acid in the abomasum can result in metabolic alkalosis.
- In sheep, no histologic lesion has been consistently associated with AED, and the etiology is unknown. In one study, histologic examination of celiacomesenteric ganglia from affected sheep revealed scattered chromatolytic or necrotic neurons, without inflammation. Chromatolytic neurons were observed more frequently in AED-affected sheep than in healthy Suffolk sheep. Neuronal necrosis was not observed in any of the healthy sheep. Neuronal lesions of AED resemble dystrophic changes of humans and other animals.

**DIAGNOSIS**

**DIFFERENTIAL DIAGNOSES**

- Includes other disorders that may cause signs of anorexia, scant fecal production, and abdominal distension including: abomasal displacement, reticuloperitonitis, lymphoma, and vagal indigestion.

**CBC/BIOCHEMISTRY/URINALYSIS**

- **CBC** is usually normal.
- **Hypochloremic, hypokalemic metabolic alkalosis may be present in chronic cases.**
- Sheep with AED do not typically demonstrate the hypochloremic, hypokalemic metabolic alkalosis commonly found in cattle with outflow obstruction disorders.

**OTHER LABORATORY TESTS**

- Elevated serum chloride concentrations in sheep (>15 mEq/L) indicate reflux of abomasal contents into the rumen.

**THERAPEUTIC APPROACH**

- Surgical therapy likely provides the greatest chance of resolution depending on the underlying cause.
- Medical therapy best accompanies surgical therapy and can consist of administration of cathartics and laxatives daily for 2 to 4 days.
- Prevention of metabolic alkalosis may be indicated in severe or chronic disease.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

- Impaction may be resolved by abomasotomy with removal of roughage or foreign material. Surgical approaches that allow access to the abomasum include right paracostal, right paramedian and right paralumbar.

**MEDICATIONS**

- Cathartic and laxative options include: magnesium sulfate (2.5 g/kg/day), mineral oil (6 mL/kg/day), and magnesium hydroxide (1 g/kg/day).
**Abomasal Impaction (Continued)**

**PREVENTION**
- Feed good-quality, long fiber-length forage with adequate energy supplementation.
- Avoid feeding on sand or gravel.

**CONTRAINdications**
- Gastrointestinal motility agents should be considered only after surgical or medical correction of impaction to reduce the risk of abomasal rupture.

**PRECAUTIONS**
- Lactated Ringer’s solution should be used cautiously due to the possibility of inducing or exacerbating metabolic alkalosis.
- Abomasal motility agents (neostigmine, metoclopramide, erythromycin, etc.) should be used with great caution to avoid abomasal rupture.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

**POSSIBLE INTERACTIONS**
N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
Grave prognosis. Death from dehydration, metabolic alkalosis or peritonitis if intervention does not occur.

**POSSIBLE COMPLICATIONS**
Abomasal rupture and peritonitis.

**CLIENT EDUCATION**
Feed cattle to meet energy requirements and avoid feeding chopped poor-quality forages with low energy, particularly in cold weather.

**PATIENT CARE**
Affected animals should be assessed for signs of pain and suffering (lethargy, inappetance, signs of abdominal pain), reduced fecal output, hydration status, and electrolyte balance.

**PREVENTION**
- Feed good-quality, long fiber-length forage with adequate energy supplementation.
- Avoid feeding on sand or gravel.

**MISCELLANEOUS**

**ASSOCIATED CONDITIONS**
Reticuloperitonitis, lymphoma, displaced abomasum.

**AGE-RELATED FACTORS**
More common in adult and pregnant animals, and mature Suffolk sheep.

**ZONOTIC POTENTIAL**
N/A

**PREGNANCY**
Pregnancy predisposes to abomasal impaction as a result of increased energy requirements, appetite, and the possible effect of size and weight of the gravid uterus on abdominal organs.

**BIOSECURITY**
N/A

**PRODUCTION MANAGEMENT**
This disorder is largely preventable through appropriate dietary management.

**SYNONYMS**
Abomasal emptying defect in sheep

**ABBREVIATION**
AED = abomasal emptying defect

**SEE ALSO**
- Abomasal Emptying Defect in Sheep
- Displaced Abomasum
- Lymphosarcoma
- Traumatic Reticuloperitonitis

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**Suggested Reading**
OVERVIEW

Abomasal ulceration represents damage to the abomasal mucosa allowing gastric acid and pepsin to diffuse into the mucosa. Abomasal ulceration can be classified as type I (nonperforating ulcers), type II (nonperforating with severe blood loss), type III (perforating with localized peritonitis), and type IV (perforating with diffuse peritonitis).

HISTORICAL FINDINGS

- Injuries to the protective mucosal layer of the abomasum allow gastric acid and pepsin to diffuse into the mucosa.
- Type I nonperforating ulcers have incomplete penetration, little local reaction, and minimal bleeding.
- Type II bleeding ulcers erode into a major blood vessel in the submucosa. There may be detachment of the abomasum and efflux of abomasal contents into the rumen. Melena is typically observed.
- Type III ulcers completely perforate the wall with leakage of fluid and local peritonitis. Adhesions form to viscera, localizing the peritonitis.
- Type IV ulcers also completely perforate the abomasum.

PATHOPHYSIOLOGY

- Type I nonperforating ulcers have incomplete penetration, little local reaction, and minimal bleeding.
- Type II bleeding ulcers erode into a major blood vessel in the submucosa. There may be detachment of the abomasum and efflux of abomasal contents into the rumen. Melena is typically observed.
- Type III ulcers completely perforate the wall with leakage of fluid and local peritonitis. Adhesions form to viscera, localizing the peritonitis.
- Type IV ulcers also completely perforate the wall; however, the subsequent fluid leakage is not contained by adhesions, resulting in generalized peritonitis.

HISTORICAL FINDINGS

- Changes in feeding, such as transition from milk to solid feed in calves or change from a high roughage prepartum diet to high concentrate postpartum diets may be involved.
- This disorder affects cattle, rarely sheep and goats.
- There are no breed or gender predispositions; however, dairy cattle may have a higher prevalence.
- Occurs in calves and adults.

PHYSICAL EXAMINATION FINDINGS

- Melena or occult blood is observed in feces.
- Possible distension of the abomasum indicated by ballottement of the ventral right abdomen.
- Pale mucous membranes and tachycardia in cases with severe blood loss or septic shock.
- Anorexia, depression, pyrexia, and abdominal pain (abdominal pain).
- Peritoneal signs of hemorrhage common in adult cattle but not calves.

DIFFERENTIAL DIAGNOSES

- Lymphoma
- Left displaced abomasum
- Abomasal volvulus or torsion
- Intussusception
- Duodenal ulcers
- Hemorrhagic bowel syndrome

MICROSCOPIC FINDINGS

- Gastric hemorrhage, elevated fibrinogen, altered total protein concentration.
- Serum chemistry might reflect chronic inflammation in type III and IV ulceration reflected by high total protein concentrations and possibly neutrophilia on CBC.

OTHER LABORATORY TESTS

- Abdominocentesis may identify peritonitis, with increased leucocyte count, phagocytosed or free bacteria, and possibly feed particles in the fluid.
- Testing for occult blood in feces may detect blood in the feces before melena is visible.

IMAGING

- Ultrasonography may show free fluid and fibrin in the abdomen.

SIGNALMENT

- Occurs in calves and adults.
- Cattle in the first month postpartum, some types of calf raising systems, and in confinement.
- Nutritional management is important.
- Cattle with bleeding ulcers have signs of anemia with blood in the distal GI tract.
- Diffuse fibroin peritonitis may be evident with fibrin on the serosal surface of the abomasum.

TREATMENT

- Treatment is typically unrewarding but should target correction of management issues (dietary, stress related), correction of concurrent disease, and addressing clinical problems related to abomasal ulceration.
- Medical therapy may include provision of antacids to protect the abomasal mucosa, removal of high energy feedstuffs, and stall confinement.
- Blood transfusion may be beneficial if bleeding ceases can be controlled, and is indicated if hematocrit declines to ≤14%.
- Broad-spectrum antibiotic therapy is indicated to prevent or address septic peritonitis.

SURGICAL CONSIDERATIONS AND TECHNIQUES

- Surgical intervention for perforated ulcers might be attempted for valuable cattle.

APPROACH

- Medical therapy may include antacids to protect the abomasal mucosa, removal of high energy feedstuffs, and stall confinement.
- Blood transfusion may be beneficial if bleeding ceases can be controlled, and is indicated if hematocrit declines to ≤14%.
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SURGICAL CONSIDERATIONS AND TECHNIQUES

- Surgical intervention for perforated ulcers might be attempted for valuable cattle.

MEDICATIONS

- Drugs of choice: magnesium oxide (500 g/400 kg body weight daily for 2–4 days), or a kaolin and pectin mixture (2–3 liters twice daily to mature cattle).
- Treatment options in calves include oral administration of antacids (20–50 mL q4h), ranitidine (50 mg/kg q8h) and omeprazole (4 mg/kg q24h).

CONTRAINdications

- NSAIDs that interfere with the production of prostaglandins E-series via the arachidonic acid cascade are not recommended, to avoid compromise of the protective coating of the abomasal mucosa.

PRECAUTIONS

- Avoid NSAIDs and curricetid drugs, particularly in susceptible populations.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.
POSSIBLE INTERACTIONS
N/A

FOLLOW-UP

EXPECTED COURSE AND PROGNOSIS
Recovery for type I and type III ulcers is considered likely or possible; type II ulcers are fatal if severe hemorrhage occurs; type IV ulcers carry a guarded prognosis.

POSSIBLE COMPLICATIONS
- Septic peritonitis as a result of abomasal leakage or perforation.
- Hepatic lipidosis as a result of anorexia, particularly in cattle in early lactation.

CLIENT EDUCATION
Gradual introduction of dry feed to calves is preferred over abrupt exposure to dry feed during the milk-fed period.

PATIENT CARE
Serial assessments of CBC, anemia, and pain are used to determine recovery over time.

PREVENTION
- Avoid rapid change from liquid to dry feed in calves.
- Avoid excessive concentrate diets in feedlot or dairy cattle.
- Cull animals infected with bovine leukemia virus to eliminate lymphosarcoma as a cause of abomasal ulceration.

ASSOCIATED CONDITIONS
Lymphoma

AGE-RELATED FACTORS
Affects all ages

ZOONOTIC POTENTIAL
N/A

PREGNANCY
N/A

BIOSECURITY
N/A

PRODUCTION MANAGEMENT
Avoid sudden dietary changes, rather, gradually introduce dry feed to calves.

SYNONYMS
N/A

ABBREVIATION
NSAIDs = nonsteroidal anti-inflammatory drugs

SEE ALSO
- Displaced Abomasum
- Hemorrhagic Bowel Syndrome
- Lymphosarcoma

Suggested Reading


Author Jim P. Reynolds
Consulting Editor Erica C. McKenzie
Abortion: Bacterial

Opportunistic bacteria

Moderate risk factors
- Inappropriate biosecurity measures and vaccination schedules
- Nutritional, social or environmental stress
- Seasonal presence of risks and vectors
- Exposure to wildlife and rodents

Diagnosis

Differential diagnoses
- Vaginitis, metritis, endometritis
- Other causes of abortion

CBC/biochemistry/urinalysis
- Hemolytic anemia and hemoglobinuria
- Other causes of abortion

Other laboratory tests
- Bacterial culture from aborted tissues (lung, abomasal contents, placenta) and dam’s milk (brucellosis)
- Dam and fetal serology
- Immunohistochemistry and/or immunofluorescence on fetal tissues
- PCR on aborted tissues (leptospirosis, brucellosis, campylobacteriosis, C. burnetii, A. phagocytophilum, C. abortus)
- Direct identification on Giemsa-stained blood smears (Anaplasma spp.)

Imaging

Other diagnostic procedures
- Fetal necropsy

Pathologic findings
- Contagious bacteria
  - R. abortus, C. fetus (subp. veterinus or fetus), C. jejuni, L. monocytogenes, H. somni, Salmonella spp., Y. pseudotuberculosis, M. bovis, C. abortus
- Tick-borne infection
  - C. burnetii, A. marginale, A. phagocytophilum, epizootic bovine abortion
- Mollicute infection
  - M. bovis, M. bovigenitalium, M. canadense, M. leachii, Ureaplasma diversum

Causes and risk factors
- Contagious bacteria
  - R. abortus, C. fetus (subp. veterinus or fetus), C. jejuni, L. monocytogenes, H. somni, Salmonella spp., Y. pseudotuberculosis, M. bovis, C. abortus
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Pathogenesis

Bacterial abortion: Last trimester pregnancy loss between 42 days and term, caused by bacterial infection

Infection occurs transplacentally, usually via inhalation or across conjunctival mucosa.
- Tick-borne vectors for epizootic bovine abortion
  - Ruminants, bovine (epizootic bovine abortion)
- Vector-borne: epizootic bovine abortion
  - Anaplasma marginale
  - Anaplasma phagocytophilum
  - Babesia microti
  - Babesia bovista
  - Babesia duncani
  - Babesia alphacanis
  - Babesia divergens
  - Babesia bigemina
  - Ehrlichia bovis
  - Ehrlichia ristiniae
  - Ehrlichia canis
  - Ehrlichia muris
  - Ehrlichia chaffeensis
  - Ehrlichia ewingii
  - Ehrlichia equi
  - Ehrlichia phagocytophila
  - Ehrlichia chaffeei
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Other laboratory tests
- Fetal necropsy
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  - Mollicute infection
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Opportunistic bacteria

Moderate risk factors
- Inappropriate biosecurity measures and vaccination schedules
- Nutritional, social or environmental stress
- Seasonal presence of risks and vectors
- Exposure to wildlife and rodents

Differential diagnoses
- Vaginitis, metritis, endometritis
- Other causes of abortion

CBC/biochemistry/urinalysis
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Other laboratory tests
- Bacterial culture from aborted tissues (lung, abomasal contents, placenta) and dam’s milk (brucellosis)
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**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
Infected or exposed cows may develop natural immunity to some bacteria, with lower rates of abortion in subsequent breeding seasons.

**POSSIBLE COMPLICATIONS**
- Dysxia
- RFM
- Metritis
- Infection

**CLIENT EDUCATION**
- Zoonotic potential. Wear protective gloves and clothes when handling aborted tissues and animals.
- Pregnant women, children, elderly and immunosuppressed people should not handle aborted tissues or tissues.
- Keep aborted tissues refrigerated and call a veterinarian.
- Proper disposal of aborted tissues.

**PATIENT CARE**
- Monitor cow for RFM and metritis.
- Monitor heifer for further abortions, stillbirths, or birth of weak calves.
- Change slage source (listerosis).
- Adjust diet to eliminate ruminal acidosis and bacterial translocation.

**PREVENTION**
- Appropriate immunization program, nutrition, and environmental management.
- Test and cull positive animals.
- Use virgin bulls and heifers for replacement.
- Use anti-parasitics.
- Use artificial insemination.
- Reduce contact with wildlife and rodents.
- Care slage property and avoid feeding spoiled material.
- Use fall calving season to prevent exposure of pregnant cows to ticks.
- Expose cows to ticks prior to breeding to stimulate natural immunity.

**AGED-RELATED FACTORS**

**ZOOOTIC POTENTIAL**
- Brucellosis, leptospirosis, listeriosis, Coxiella burnetii, Chlamydia abortus, and salmonellosis

**PREGNANCY**

**BIOSECURITY**
- Brucellosis and tuberculosis are reportable diseases.
- See “Prevention.”

**PRODUCTION MANAGEMENT**
- See “Prevention.”

**SYNONYMS**
- CL = corpus luteum
- RFM = retained fetal membranes

**SEE ALSO**
- Abortion: Bovine
- Abortion: Fungal, and Nutritional
- Brucellosis
- Campylobacter
- Chlamydia
- Listeriosis
- Q Fever (Coxiella)
- Vaccination Programs: Beef Cattle
- Vaccination Programs: Dairy Cattle

**Suggested Reading**
- Author Maria Soledad Ferrer Consulting Editor Ahmed Thirary

**ACKNOWLEDGMENT**
The author and book editors acknowledge the prior contribution of Walter Johnson and Alex Estrada.
Abortion: Bovine

**BASICS**

**OVERVIEW**

Abortion in cattle is defined as loss of the fetus from 42 days to term. Prior to 42 days, pregnancy loss is considered embryonic mortality.

**INCIDENCE/PREVALENCE**

• Should be <1% on a herd basis (<1–2% ideal).
• Abortion storms may occur in the case of specific infectious diseases.
• In a 10-year study on bovine abortions and stillbirths, bacteria were determined to be the cause of 14-49% of the cases. The five bacteria most commonly associated with bovine abortion in the study were: *Treponema pyogenes, Bacillus spp., Listeria spp., E. coli,* and *L. interrgent.*

**GEOGRAPHIC DISTRIBUTION**

Worldwide.

**SYSTEMS AFFECTED**

• Reproductive
• Other systems depending on cause.

**PATHOPHYSIOLOGY**

• Cattle rely primarily on the corpus luteum (CL) for production of progesterone for the first 180–200 days of gestation, followed by a shift to production of progesterone by the placenta in late gestation.
• Abortion may be caused by infectious or noninfectious etiologies.
• Infectious causes of abortion include bacteria, viruses, fungi, and protozoa.
• Bacteria involved in abortion can be grouped into contagious and opportunistic.
• Ability of a pathogen to damage the conceptus is influenced by the dam, stage of fetal development, and virulence of the infecting agent.
• The time between fetal death and expulsion may be characteristic for a pathogen.
• Noninfectious causes of abortion include nutritional imbalance, copper drug administration, malnutrition, stress, external toxins, teratogenic compounds, hormone imbalances, and genetic anomalies.
• Abortion may result due to fetal death following:
  - Infection by microorganisms through hematogenous spread, ascending infection or presence of organism in the uterus prior to conception.
  - Placental disease or insufficiency due to hematogenous (umbilical veins) or amniotic fluid (i.e., fungal infections) contamination.
• Some pathogens may cause severe placentalitis leading to fetal hypoxia and death.
• Maternal compromise (manure, pneumonia, circulatory disorder, hypoxia, endotoxemia, etc.).
• Severe congenital malformations in some etiologies.

**HISTORICAL FINDINGS**

• Introduction of new animals
• Return to receptivity after confirmation of pregnancy
• Bloody or mucopurulent vaginal discharge in the pregnant cow
• Postmortem/exploration of the placenta or fetus
• Premature development of the mammary gland and lactation

A complete history should be taken from each aborting case and include the following information:

- Age, breed, lactation parity, clinical signs of the aborting female.
- Reproductive history (i.e. breeding technique, breeding dates).
- Individual case vs herd outbreak.
- Number of abortions.
- Health problems/body condition.
- Herd abortion history.
- Treatments and vaccination administered in the preceding 2 weeks.
- Animal movement within the last month.
- Previous abortions and any workup performed.
- Feeding/nutritional management, quality of pasture (toxic plants).
- Layout of the facilities (water sources, proximity to other operations, etc.).
- Contact with wildlife or feral cats and dogs.

**SIGNS**

- Females of breeding age.

**PHYSICAL EXAMINATION FINDINGS**

- Physical examination findings and evidence of abortion will depend on the stage of gestation and the cause of abortion.
- Clinical examination of the cow(s) should be taken into consideration:
  - Body condition score.
  - Thorough physical examination including temperature, pulse, respiration, mucous membrane color, hydration status, presence of vaginal discharge, etc.
- Demenation.
- Visual abnormalities.

**GENETICS**

N/A

**CAUSES AND RISK FACTORS**

- Causes of abortion can be classified as infectious (viral, bacterial, protozoal, fungal) or noninfectious (iatrogenic, maternal, fetal/placental, nutritional).
- Noninfectious causes of abortion may be sporadic or affect several animals in the herd (nutritional deficiencies or administration of certain drugs).
- Infectious abortions are more likely to affect several animals within the herd simultaneously.
- Risk factors include lack of biosecurity measures, presence of vectors or toxins, overcrowding, etc.

**DIAGNOSIS**

- The etiology of abortion is often difficult to determine and can be frustrating for owners and practitioners.
- Even when all required samples are submitted, the diagnostic rate is only 50%.
- Abortion frequently results from an event that occurred weeks to months prior to the abortion event, making the diagnostic difficult in many cases.
- Evaluation should include:
  - Uterine cytology and culture (sent in some cases).
  - Pathology.
- Samples should be taken from the fetus (cardiac blood), from the aborting dam (paired samples) at abortion and 2 to 3 weeks later, and from at-risk pregnant females in the face of an outbreak.
- Samples from 10% of the herd will make serological assessment more meaningful.
- Bacteriology/Virology
- Samples should be taken from the fetus (stomach content, fetal fluids both thoracic and abdominal, kidney, liver, lung, spleen, and thymus), from the dam (vaginal discharge, uterine swab), and from the placenta.
- Samples should be collected using aseptic technique into sterile bags, refrigerated, and submitted to the diagnostic laboratory for further evaluation.
- Necropsy/Histopathology
- Digital photographs are helpful for documenting lesions.
- A complete set of tissues should be collected in every case.
- Fetal necropsy.
- Measurement of the crown-rump length and weight.
- External evaluation of the fetus for developmental abnormalities or lesions and evidence of autolysis, maceration, or mummification.
- Internal evaluation of the fetus. Either the entire fetus (optimal) or samples from the liver, brain, thymus, heart, spleen, kidney, stomach, lungs, skeletal muscle, were submitted in formalin and fresh chilled to a diagnostic laboratory for further evaluation. Collection of colostrum fluid (fetuses) for nitrate/nitrite levels.
- Placental examination:
  - External examination of the chorioallantois (including the chorion and amnion).
  - External examination for signs of placentitis (thickening, degradation, edema).
  - Examination for developmental abnormalities or lesions of the umbilical cord.
  - Make impression smears of any lesions.
- Either the entire placenta or samples of both uterine horns and uterine body (cortyledon and intercortyledory area) along with any subjective abnormal areas should be submitted in formalin and fresh chilled for further evaluation.

**DIFFERENTIAL DIAGNOSES**

**Infectious Causes of Abortion**

- Viral causes of abortion:
  - Bovine viral diarrhea virus (BVDV).
  - Bovine herpesvirus 1 (BHV-1, infectious bovine rhinotracheitis; abortion storms affecting 25–60% in naive pregnant cattle).
  - Bovine herpesvirus 4 (BHV-4, often associated with other pathogens).
  - Bluetongue virus (RTV).
  - Epizootic hemorrhagic disease virus (EHDV).
  - Rift Valley fever philovirus (RVF; mortality range 10–70% and abortion occurring at any gestational age reaching 80–90%).
  - Akabane virus.
  - Schmallenberg virus.
  - Bacteriological causes of abortion:
  - Brucellosis (B. abortus; in susceptible herds, abortion rates may be as high as 70%).
  - Leptospirosis (L. interrogans). Leptospirosis, abortions sporadic and rarely >15%.
  - Campylobacteriosis (C. fetus subsp. fetus; abortions <10% in infected herd).
  - C. fetus subsp. fetus, C. jejuni.
  - Leporrhospiria (L. interrogans) sarcozoon Hardjo and Pomona most important causes of abortion, losses of...
up to 50% may be experienced in some outbreaks.  

1. Tuberculosis (Mycobacterium bovis, M. caprae)  
2. Epizootic bovine abortion.  
3. Histophilus somni (formerly Haemophilus somni)  
4. Salomonella spp.  
5. Pasteurella spp.  

- Adrenal gland dysfunction (particularly in C. psittaci.  
- Neospora caninum  
- Oxyuris dentis  
- Campylobacter rodhochrous  
- Mycoplasma bovis  
- Mycoplasma dispar  
- Leptospira  
- Tuberculosis  

**PREGNANCY**  
N/A  

**BIOSECURITY**  
See "Prevention"  

**PRODUCTION MANAGEMENT**  
N/A  

**SYNONYMS**  
N/A  

**ABBREVIATIONS**  
N/A  

**SEE ALSO**  
- Abortion: Viral, Fungal, and Nutritional  

**Suggested Reading**  

Author Alexis Campbell  
Consulting Editor Ahmed Tliby
**BASICS**

**OVERVIEW**
Abortion is defined as loss of the fetus from 42 days to term. Prior to 42 days, pregnancy loss is considered embryonic mortality.

**INCIDENCE/PREVALENCE**
- Pregnancy loss ranges from 2 to 17%.
- Losses of up to 60% may be experienced in some leptospirosis outbreaks (i.e., *Leptospira, Brucella*).
- Loss of 40-50% have been reported in maiden females under some management systems.

**GEOGRAPHIC DISTRIBUTION**
Worldwide with some regional differences.

**SYSTEMS AFFECTED**
- Reproductive
- Other systems depending on cause and complications

**PATHOPHYSIOLOGY**
- Camels rely primarily on the corpus luteum (CL) for production of progesterone and maintenance of pregnancy for the entire gestation.
- Abortion is caused by any factor that causes directly or indirectly luteolysis:
  - **Treatment with prostaglandin F2**: Inhibits luteal function.
  - **Inflammatory or infectious process**: Causes luteolysis.
  - **Endotoxemia**: Causes luteolysis.
  - **Stress**: Stress such as heat stress or transport results in stress.
  - **Debilitating diseases**: Can cause luteolysis.
  - **Abortion can be caused by compromised fetal viability or placental integrity**:
    - **Placental**: Causes fetal death.
    - **Placental insufficiency (endometrial fibrosis, uterine capacity in maiden females, twinning)**: Causes fetal death.
    - **Direct insult to the fetus (mechanical or infection)**: Causes fetal death.
    - **Fetal malformation/abnormal pregnancy**: Causes fetal death.
    - **Premature development of the mammary system**:
      - **Omphalolecithosis**: Leads to fetal death.
      - **Some multivalent vaccines (8-way vaccines spp.)**: Can cause fetal death.

**HISTORICAL FINDINGS**
- Presenting complaints may include:
  - Return to receptivity after confirmation of pregnancy
  - Bloody or mucopurulent vaginal discharge in the pregnant female
  - Postmortem/exploration of the placenta or fetus
  - Premature development of the mammary gland and lactation
- A complete history of the aborting female(s) should include the following information:
  - **Age**: Age of the female
  - **Reproductive history (breeding technique, pregnancy diagnosis, breeding dates)**: Breeding history.
  - **Treatments and vaccination administered in the preceding 2 weeks**: Vaccination history.
  - **Animal movement within the last month**: Movement history.
  - **Possibility of heat stress**: Heat stress history.
  - **Feeding management**: Feeding history.

**PHYSICAL EXAMINATION FINDINGS**
- **Females of breeding age**
- **Abortion of noninfectious origin is usually sporadic. However, several animals in the herd may be affected in the case of nutritional deficiencies or administration of certain drugs.**
- **Infectious abortions are more likely to affect several animals within the herd simultaneously.**

**CAUSES AND RISK FACTORS**
- **Infectious causes of abortion**:
  - **Bovine viral diarrhea virus** (most common serotype affecting alpacas and llamas is noncytopathic BVDV-1b)
  - **Equine herpes virus-1 (potential)**
  - **Blue tongue virus (potential)**
  - **Brucellosis**:
    - B. melitensis
    - B. abortus
  - **Listeriosis**
  - **Chlamydiosis** (Caninales borreli, well-established cause of abortion in camels)

**Differential Diagnosis**
- **Evaluation of the female should include**: Neutrocytosis, culture, and biopsy may be indicated in some cases.
- **Serology**:
  - Samples should be taken from the fetus (cardiac blood), from the aborting dam (paired samples) at abortion and 2 to 3 weeks later, and from at-risk pregnant females in the face of an outbreak.
- **Bacteriology**:
  - Samples should be taken from the fetus (stomach content, fetal fluids both thoracic and abdominal), from the dam (vaginal discharge, uterine swab), and from the placenta.
- **Serology/Histopathology**:
  - Fetal necropsy:
    - Measurement of the crown-rump length.
    - External evaluation of the fetus for developmental abnormalities or lesions.
  - **Either the entire fetus or samples from the liver, brain, spleen, kidney, stomach, and lung should be submitted fixed in formalin and fresh chilled to a diagnostic laboratory** for further evaluation.
  - **Placentology**:
    - External examination of the chorionic surface for lack of villi (placental insufficiency) or signs of placental necrosis (thickening, degradation, edematous).
    - The umbilical cord is examined for abnormalities or inflammatory lesions.
    - The entire placenta or samples of both uterine horns and uterine body, along with any abnormal areas, should be submitted fixed in formalin and fresh chilled for further evaluation.
- **Endoscopy**:
  - In cases of habitual abortion, progesterone determination during pregnancy may be indicative of possible luteal insufficiency.
  - Pregnant females with progesterone levels...
<2 ng/mL should be considered suspicious. However, some females may be able to carry a pregnancy to term even if progesterone levels are 1.5–2 ng/mL.

**MEDICATIONS**

- PROGESTERONE
- HYDROXYPROGESTERONE CAPROATE
- NORGESTOMET
- ALTRENOGEST
- PGF2α

**PREVENTION**

- Observe strict hygiene in breeding management.
- Set up guideline for biosecurity: quarantine new animals; during movement of animals between shows and ranch, visiting animals for breeding.
- Isolate any aborting female until diagnosis is established.
- Vaccination for leptospirosis (4 times a year).

**ASSOCIATED CONDITIONS**

- Infertility, dystocia, poor systemic health
- Fetal abnormalities

**AGE-RELATED FACTORS**

- ZOONOTIC POTENTIAL
- Possible for brucellosis (B. melitensis, B. abortus), Chlamydia abortus, leptospirosis, Q fever

**PREGNANCY**

- BIOSECURITY
- See "Prevention"

**PRODUCTION MANAGEMENT**

- SYNOPSIS
- ADEQUATE NUTRITION, PARASITE CONTROL, AND SUPPORTIVE CARE ARE IMPORTANT IN DEBILITATED ANIMALS.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

- Fetal viability should be monitored regularly if progesterone supplementation is implemented.
- Adequate nutrition, including balanced trace minerals, for the herd is important for eliminating some of the causes of abortion.
- Adequate nutrition, parasite control, and immunization programs for the herd are important for preventing some causes of abortion. Segregation of animals based on sex, age, and pregnancy status may help reduce transmission of infectious organism.

**OTHER LABORATORY TESTS**

- See "Diagnosis"

**OTHER DIAGNOSTIC PROCEDURES**

- Studies on pathological findings in camelid abortion are scarce.
- Pathological examination of placentas from aborted, large avillous areas are seen on the placenta.
- Placentitis is a common feature in bacterial abortion.
- Studies on pathological findings in camelid abortion are scarce.
- Fetal abnormalities are common.

**IMAGING**

- Early diagnosis and termination of twins.
- Adequate nutrition, parasite control, and immunization programs for the herd are important for preventing some causes of abortion.
transrectal palpation (in wapiti) or transrectal fetal/embryonic loss can be confirmed by expelled fetus. Imminent parturition (i.e., seeking isolation, impending or unobserved late-term abortion ◦ Presence of expelled fetus and/or placenta ◦ Bloody or purulent vaginal discharge
HISTORICAL FINDINGS
If fetus is resorbed early in gestation, there may be no findings except missed due date from an expected or confirmed pregnancy. If abortion occurred early in the season, the female may come back into estrus. If abortion occurred early in the season, the female may give birth much later than the rest of the herd or remain pregnant. If abortion occurred late in the pregnancy, discovery of expelled fetus. Female may show signs of imminent parturition (i.e., seeking isolation, restlessness) before expected due date.

OVERVIEW
• Definition: Loss of an embryo or fetus
• Causes may be infectious, environmental, congenital or idiopathic

INCIDENCE/PREVALENCE
The incidence of pregnancy loss in farmed deer is relatively low.

GEOGRAPHIC DISTRIBUTION
N/A

SYSTEMS AFFECTED
• Reproductive: Others depending on cause

PATHOPHYSIOLOGY
• Pathophysiology depends on etiology.

CAUSES AND RISK FACTORS
The major risk factors for abortion are poor herd management ranging from inadequate nutrition to stressful handling to poor biosecurity protocols.

BASICS
Commonly studied species include those within the genera Cervus (red deer, wapiti), Elaphus (fallow deer), Axis (chital deer), Reindeer (reindeer), Ozotoceros (black-tailed deer, mule deer), Cervus (Conee deer, Capreolus (roe deer), Bovidae (Père David’s deer), Rucervus (swamp deer, Barasingha), females of breeding age.

PHYSICAL EXAMINATION FINDINGS
Likely no visible sign if fetal resorption occurred early in gestation. If suspected, fetal/embryonic loss can be confirmed by transrectal palpation (in wapiti) or transrectal ultrasonography. A female with an impending or unobserved late-term abortion may exhibit the following clinical signs:
• Bloody or purulent vaginal discharge
• Presence of expelled fetus and/or placenta
• Premature vulval development and dripping
• Non-specific signs of illness, such as depression, dehydration, pyrexia, anorexia, or weight loss.
• An impending late-term abortion may be suspected if the female begins showing signs of imminent parturition before expected due date.
• Late-term abortions in cervids may go unobserved if the female eats the placenta and/or a predator consumes the dead fetus. Observation of alternative clinical signs or ultrasound may be able to confirm the loss of a fetus.
• Brucellosis-induced abortion in female reindeer is characterized by retained placenta and metritis. Bovine viral diarrhea virus and cervid herpesvirus 2 can both cause ulceration of the cervix and uterus in cervids. • Listeriosis: The septicaemic form has been reported to cause placental and endometritis in farmed red deer, leading to abortion in late-term pregnancy and birth of weak, full-term young. It should be considered as a potential cause of abortion in any cervid species.

Fungal Causes
Incidence of fungal infections in cervid species is very low.

Parasitic Causes
Toxoplasma gondii: Toxoplasmosis has been associated with encephalitis and placentalitis in a full-term stillborn reindeer fetus. In red deer, seropositive females experience adverse effects on fetal development. Neospora caninum: Seroprevalence in asymptomatic animals has also been reported in many cervid species; however, there have been reports associated with full-term stillborn Elks’ deers and perinatal death in fallow deers and axis deer, due to suspected vertical transmission.

Viral Causes
Bluetongue (BTV; orbivirus): Infection of cervid species generally leads to hemolytic disease and death. Under experimental inoculation, early embryonic absorption and fetal death were both reported in white-tailed deer. Bovine viral diarrhea virus and BVDV; pestivirus: Usually resulting in widespread hemolysis, dehydration, and sudden death. EHDV has been reported to cause abortion and congenital lesions in cattle and, therefore, cannot be ruled out as a potential cause of fetal death in deer. Brucellosis-induced abortion in female cervids is very low.

Abortion and stillbirth have been reported in several cervid species due to toxoplasmosis. The deficiency may be caused by insufficient dietary intake, or by secondary to excessive calcium in the diet, ingestion of toxic plants such as Brassica spp., gross bacterial contamination of the feed, continuous intake of feeds containing cyanogenic glucosides (e.g., white clover), or ingestion of canola (rapeseed and canola meal). Vitamin E and/or selenium deficiency: Congenital white muscle disease has been reported in several deer species and can be fatal to the neonate.

Bacterial Causes
Brucella abortus: Biurakos 1 and 4 have been recovered from wild elk in the Yukon area of the US. Natural infections have not been reported in white-tailed deer or mule deer, but experimental infections have been established in both, suggesting possibility for interspecies transmission. Leptospirosis: Studies in red deer showed reproductive effects, mostly reduced weaning rates, but no reports of abortions. Abortions following experimental inoculation with L. pomona have been demonstrated in white-tailed deer, demonstrating its abortogenic potential in cervid species. Listeriosis: The septicaemic form has been reported to cause placental and endometritis in farmed red deer, leading to abortion in late-term pregnancy and birth of weak, full-term young. It should be considered as a potential cause of abortion in any cervid species.
Abortion: Farmed Cervidae (Continued)

Other Causes
• Other causes of abortion or stillbirth include toxicoses, traumatic injuries, congenital abnormalities, and administration of some drugs.
• Laceration causes abortions in sheep and cattle and may be a problem for cervidae as well. • Congenital abnormalities, fetal overseas, or abnormalities of presentation at time of parturition are rare, but may lead to dystocia and subsequent fetal death.
• Prostaglandins and steroids can induce fetal expulsion.

Diagnosis
Differential Diagnoses
• Vaginal discharge • Normal term parturition • Vaginitis • Pyometra • Metritis • Uterine trauma or hemorrage • Uterine or vaginal neoplasia • Misssed due date • Infertility, either male or female (if pregnancy was not confirmed) • Inconcer due date • Signs of impending parturition before due date • Isolation: may indicate neonologic disease • Abdominal straining: colic due to bloat (foal hy vs. fever gas) or other GI disease.

CBC/Chemistry/Urinalysis
Little data is available on routine analyses but may be extrapolated from domesticated ruminants and on cause of abortion.

Other Laboratory Tests
Pregnancy Diagnosis and Monitoring
• Transrectal ultrasonography: Can be performed in smaller cervid species as early as 35 days and used to count the number of fetuses if performed within the first 2 trimesters.

Other Diagnostic Procedures
 Necropsy and sample collection of aborted fetus and placenta should occur as soon as possible to minimize secondary bacterial overgrowth. It may be difficult to obtain the placenta as the female usually ingests it. In herd outbreaks, it may be worthwhile to sacrifice a female for postmortem diagnosis if fetal tissues are inconclusive. Paired serology is most effective for verifying the diagnosis.

Parasitic Abortions
• Toxoplasmosis or Neospora: Serology - indirect or direct hemagglutination, indirect immunofluorescent antibody test ELISA.

Viral Abortions
• BTV or EHDV: Serology (competitive ELISA, agar gel immunodiffusion, microtiter virus neutralization [MVN]); IHC, PCR, virus isolation of aborted tissue. • BVDV: Paired serology (MVN, ELISA); virus isolation from blood or nasal secretions; IHC of aborted tissue. • CxHV-2: Serology (ELISA); PCR from tissue samples, nasal swabs, trigeminal ganglia samples.

Pathologic Findings
• Necropsy: Gross lesions in aborted white-tailed deer fetuses (following experimental inoculation with T. gondii) included swollen, hemorrhagic, pulpy kidneys, liver, and lymph nodes. • Later: Evidence of fibrous membranes on necrotizing placenitis on histopathology; fetuses may have either no gross lesions or supplicative pneumonia and meningitis.

Parasitic Causes
Toxoplasmosis: Necrotizing placenitis and multifocal nonsuppurative encephalitis of the fetus with presence of tissue cysts histologically in sections of brain and tachysites in placenta and myometrium that stain positive with Z. gondii antibodies.

Viral Causes
• BVDV: Abortion patterns are similar to those observed in cattle with fetal death occurring at variable stages of gestation, resulting in variable autolysis or mummification and a variety of dystocias.

Differential Diagnoses
• CxHV-2: No specific gross pathologies have been described in aborted fetuses, but severe autolysis has been noted. Affected reindeer cows have demonstrated mild to moderate intestinal verminous pneumonia.
• Fungal Causes
• Granulomas (goss), fungal hyphae (histopathology) on affected organs.

Treatment
Therapeutic Approach
N/A

Surgical Considerations and Techniques
N/A

Medications
• Drugs of Choice
• Broad-spectrum antibiotics indicated for specific bacterial diseases; long-acting antibiotics require less frequent dosing and will help to minimize stress of handling.

Other Considerations
N/A

Precautions
N/A

Possible Interactions
N/A

Follow-Up
Expected Course and Prognosis
• Decreased fertility, increased morbidity in females. • Dystocia, uterine infection.

Client Education
See “Biosecurity” and “Production Management.”

Patient Care
• In cases of single abortion, important to watch entire herd to ensure no outbreak ensues. • Appropriate health care should be
provided based on the underlying etiology.

- Supportive care (IV fluids, anti-inflammatories or antibiotics) for systemic illness.
- If suspected nutritional issue, have feed analysis performed to determine underlying deficiency or toxicity. Change feed or supplement nutrients as necessary. If histopathology or microbiology are suspected, make appropriate changes to silage feeding practices.

PREVENTION

Establish a good nutritional and preventive health program.

**Brucellosis**

- USDA-APHIS have published minimum program standards and procedures to eradicate and monitor brucellosis in farm or ranch-raised deer. Required cervid surveillance identification tests include: - Intersite movement tests: All sexually intact animals 6 months of age or older must test negative for brucellosis within 30 days prior to interstate movement, with a 90-day post-movement test strongly recommended. - Slaughter establishment tests: All test-eligible animals are blood-sampled at slaughter and tested for brucellosis. - Certified brucellosis-free cervid herds are exempt from testing requirements for interstate movement. - In infected herds, test and removal programs may be practical for intensively managed deer farms but not for age or wildlife parks. - No recommended vaccine is currently available for most cervid species. - Brucella suis biovar 4 (killed) vaccine has been shown to be useful for providing protection in reindeer.

**Leptospirosis**

- Extra-label use of cattle vaccine available in the US.

**Bluetongue and EHD**

- Parasite control should be implemented to decrease the number of arthropod vectors (e.g., Culicoides spp. or gnats). - Autogenous vaccines are available through Newport Laboratories.

**BVDV**

Fencing of adequate height and double fencing are recommended in order to prevent direct contact and disease transmission between captive and wild cervids.

**Abortion: Farm Cervidae**

**AGE-RELATED FACTORS**

N/A

**ZOONOTIC POTENTIAL**

Brucellosis, toxoplasmosis, leptospirosis, and listeriosis are all zoonotic diseases, appropriate precautions should be taken when handling fetal or placental tissues.

**PREGNANCY**

N/A

**BIOSECURITY**

- Quarantine newly acquired animals for 30 days minimum, then pre-purchase testing for infectious diseases.
- Double fences to minimize direct contact with wildlife species.

**PRODUCTION MANAGEMENT**

- Monitoring birthweight and growth of young animals and keeping records of previous reproductive performance of females will allow owners to make appropriate herd management decisions.
- Habituating animals to gates and chutes makes handling during physical exams and other routine procedures less stressful on the animals. - Adequate nutritional management is crucial. Females should have a body condition score of 3-5 out of 9 to even be considered for breeding. Overweight females may be at increased risk for dystocia whereas underweight females are at an increased risk for abortion. - Close monitoring during gestation will be beneficial in the event of an abortion. - If suspected nutritional deficiency or toxicity, make appropriate changes to silage feeding practices.

**SYNONYMS**

N/A

**ABBREVIATIONS**

- BTV = bluetongue virus
- BVDV = bovine viral diarrhea virus
- CF = complement fixation
- CAHV = cervine herpesvirus
- EHDV = epizootic hemorrhagic disease virus = ELISA = enzyme-linked immunosorbent assay = IHC = immunohistochemistry = MAT = microscopic agglutination test = TTD = pregnancy-induced leukemia glucosaminidase = PI = persistently infected = PSPB = pregnancy-specific protein B = SPT = standard plate agglutination test

**SEE ALSO**

- Abortion: Bacterial
- Abortion: Small Ruminant
- Abortion: Viral, Fungal, and Nutritional
- Bovine Viral Diarrhea Virus
- Brucellosis
- Cervid: Biosecurity
- Cervid: Breeding Soundness Examination
- Cervid: Reproduction
- Cervid: Vaccination Programs

**Suggested Reading**


Authors Jamie L. Stewart and Clifford F. Shipley

Consulting Editor Ahmed Tihary


A B O R T I O N :  S M A L L  R U M I N A N T

**BASICS**

**OVERVIEW**
- Fetal loss, fetal wastage: conceptus loss at any time during pregnancy. * Most commonly observed in the last 2 months of pregnancy.

**INCIDENCE/PREVALENCE**
- Flock pregnancy loss should be >5% (<2% ideal). * Abortion storms may occur in the case of specific infectious diseases.

**GEOGRAPHIC DISTRIBUTION**
- Worldwide. * Some diseases processes may be regional (presence of vector).

**SYSTEMS AFFECTED**
- Reproductive. * Other systems depending on etiology.

**PATHOPHYSIOLOGY**
- Abortion results from:  
  - Fetal death from invasion by microorganisms or subsequent to placental disease (placitis, vasculitis) and placental insufficiency. * Fetal expulsion or premature parturition may result from maternal compromise. * Realignment, maceration, mummification, and autolysis may be observed in some cases. 
  - Fetal abnormalities are often a feature of some viral infections. * Causes include a variety of infectious and noninfectious agents.

**GENETICS**
- Angora goat may be a habitual aborter.

**HISTORICAL FINDINGS**
- Premature/stillborn. * Increased congenital abnormalities in neonates or fuses.

**SIGNALMENT**
- Nonsporadic. * Females of breeding age that were exposed to the male or inseminated.

**PHYSICAL EXAMINATION FINDINGS**
- Macroparturient or homorragic vaginal discharge containing fetal membranes in early pregnancy loss. * Signs of abortion: vaginal discharge vulvar edema, retained placenta. * Systemic signs such as fever, anorexia may be present. * Other signs in flock: abnormal fuses, sick or ill-thrift lambs and kids. * Clinical signs in the aborting female vary depending on the cause. * Complications depend on cause (deterioration of health, retained placenta, mertitis).

**CLINICAL SIGNS**
- Several infectious abortions are subclinical in the dam (Cache Valley, Border disease, caprine herpesvirus, Schmallenberg, Q fever).
- Septicemia, fever, decreased appetite, reduced milk production, abortion, and meningitis/encephalitis. * Mycoplasmosis (goats): Mertitis, arthritis, keratoconjunctivitis, vulvovaginitis, and abortion in the last 12th of pregnancy.

**CAUSES AND RISK FACTORS**
- Causes of abortion include:  
    - Lack of biosecurity measures. * Vector or reservoir population: bluetongue, CVV, Rift Valley fever. * Akabane, Nairobi sheep disease, Wesselsbron disease virus. * Neospora - PCR techniques are available. * Demonstration of organism by Ziehl-Neelsen staining. * Complement fixation: Need samples from several animals. * Fluorescent antibody test may be used to identify organism in frozen section of placenta.

**DIAGNOSIS**

**DIFFERENTIAL DIAGNOSES**

**Brucellosis**
- Isolation: Best samples are vaginal discharges and milk, stomach contents. * Indirect diagnosis: Complement fixation, agglutination, and precipitin tests may help identify carrier animals.

**Chlamydiosis (Enzootic Abortion)**

**Toxoplasmosis**
- Goats more susceptible than sheep.

**Q Fever (Coxiella burnetii)**
- Placentitis, placental colour, thickening of the intercotyledary area. * Abortion and stillbirth. * Isolation: Placenta, vaginal discharges, fetal stomach content. * PCR techniques are available. * Demonstration of organism by Ziehl-Neelsen staining. * Complement fixation: Need samples from several animals. * Fluorescent antibody test may be used to identify organism in frozen section of placenta.

**Campylobacteriosis**

**Neosporosis**
- Necrotic lesions in chorionic villi, arterioles and thrombosis of the hilus of the placemors.
Isolation and Identification

- Samples: Placenta and vaginal discharges, frozen fetal stomach content (–20°C).
- Transport medium required. * Isolation from placenta, vaginal discharge, fetal stomach content.

Salmonellosis


Border Disease

- Goats may be born weak or develop bronchopneumonia. Placemtis, placental edema. * Direct diagnosis: Culture from fetal tissues taken aseptically may be preserved at –20°C; placenta and uterine discharges.

Listeriosis (Listeria monocytogenes)

- Gram-positive, non-acid-fast facultative microaerophilic organisms. L. monocytogenes affects sheep and goats. L. innocua affects sheep only. * Females may show fever, depression, and anorexia prior to abortion mid to late pregnancy. Stillbirths, birth of weak lambs, and retained placentas are common. Females may be euthanized.

- Direct diagnosis: Placenta, fetal liver and spleen, fetal stomach content, vaginal discharge, frozen fetal stomach content (–20°C) immediately.

- Isolation: Aseptic samples taken aseptically may be preserved at –20°C; placenta and uterine discharges.

- Indirect diagnosis: Serogelatinization.

- Virus isolation: Buffy coat fraction (BCF) or glycerol. Leptospira 100 mL extender

- For histopathology: 0.5 cm section of tissue in 10% formalin 1:10. For histopathology: 0.5 cm section of tissue in 10% formalin 1:10.

- For serology: Paired sera.

- For biochemistry/urinalysis: May be indicated if aborting dams are clinically sick.

Other Laboratory Tests

- Viremic animals: Buffy coat fraction (BCF) or glycerol. Leptospira 100 mL extender

- Tissue samples from all fetal organs (spleen, liver, kidneys, brain, lymph nodes, spinal cord) should be taken in an aseptic manner immediately after abortion or death.

- Collect in sterile manner.

- Vaginal/uterine swabs

- Tissue samples from all fetal organs (spleen, liver, kidneys, brain, lymph nodes, spinal cord) should be taken in an aseptic manner immediately after abortion or death.

- Handle in the same manner as for placenta. * Fetal fluids

- If fetus is not autolyzed: ★ Stomach content

- Perirenal/thoracic fluids

- Blood from the cardiac cavity

- Milk: Samples of milk are taken from both glands using aseptic techniques (clean the mammary gland, disinfect teats, and eliminate the first 2 jets).

- Blood: ★ For isolation: immediately after/during abortion. ★ For serology: paired samples immediately after abortion and 2 to 3 weeks later. In case of an outbreak, blood should be collected from aborting females as well as from lambs/kids before colostral intake.

PATHOLOGIC FINDINGS

Abortion Associated with Deformities


- Cache Valley virus: Arthropoxysis, brachynagia, hydrencephaly, microcephaly, spinal cord hypoplasia, and mummification.

- Border disease virus: Cerebellar hydrencephaly, hydrencephaly, arthropoxysis. Dark pigmentation of the fleece, hairy shaker.

- Toxic plants: Lupine, brassica, bocconia, Sudan grass. ★ Indolone, copper, magnesium deficiency.

TREATMENT

THERAPEUTIC APPROACH

Depends on etiology and complications following abortion.

SURGICAL CONSIDERATIONS AND TECHNIQUES

DRUGS OF CHOICE

- Depends on etiology and complications following abortion. Daily tetracycline treatment of the flock may help with some of the abortion-causing diseases.


- Mycoplasma: Tetracycline and tylosin

CONTRAINDICATIONS

Appropriate milk and meat withdrawal times must be followed.

PRECAUTIONS

P. POSSIBLE INTERACTIONS

N/A
Abortion: Small Ruminant (Continued)

**Follow-up**

Expected Course and Prognosis

Dependent upon underlying cause.

**Possible Complications**

Dystocia, retained placenta, metritis, mastitis, male infertility (brucellosis, chlamydioidosis), female infertility, poor lactation, neonatal losses.

**Client Education**

- Establish good preventive program (biosecurity measures, vaccination, good nutritional programs).
- Consider every case of abortion as a possible outbreak.
- Act quickly and help collect appropriate samples to be examined by a veterinarian.
- Zoonotic risk awareness.

**Patient Care**

- Frequent monitoring of late term females in the entire herd or flock.
- Correct nutritional deficiencies if suspected.
- Avoid toxic plants and mycotoxins if suspected.

**Prevention**

- Ausen disease risk and set up preventive measures.
- Toxoplasmosis: cat population.
- Leptospirosis: rodent population, humid barn environment, proximity to dairy and swine operation.
- Salmonellosis: source of infection; bird, cattle, wildlife, predisposing conditions; overcrowding, shipping, climatic changes.
- Chlamydioidosis: Infection transmission: placenta, fetal fluids.
- Pigeon/sparrows are reservoirs, ticks or insects may play a role.
- Mycoplasma may play a role.
- Avian flu: transmission: placenta, fetal fluids.
- Salmonella: autogenous vaccines in conjunction with chlortetracycline may help.
- R. equi: poor efficacy of killed vaccine.
- Brumeliiosis (B. melitensis): live attenuated good vaccine may be helpful.
- Toxoplasmosis: may be helpful.

**Miscellaneous**

**Associated Conditions**

- N/A

**Age-Related Factors**

- N/A

**Zoonotic Potential**

- Campylobacter jejuni (aborted fetus, stomach content, fetal membranes).
- C. abortus (fetal membranes, vaginal discharge).
- Q fever (influenza-like symptoms, myalgia, endocarditis).
- Brucellosis (B. melitensis, Malta fever, undulating fever, joint pain).
- Listeriosis.

**Pregnancy**

- N/A

**Biosecurity**

See “Prevention”.

**Production Management**

- Call infertile animal.
- Quarantine measures.

**Synonyms**

- N/A

**Abbreviations**

- ELISA = enzyme linked immunosorbent assay.
- IFNA = indirect inclusion fluorescence antibody.
- PCR = polymerase chain reaction.
- RVF = Rinderpest disease virus.
- CpHV-1 = caprine herpesvirus-1.
- RVP = Rift Valley fever.

**See also**

- Abortion: Bacterial.
- Abortion: Viral, Fungal, and Nutritional.
- Akabane.
- Arthritis.
- Brucellosis.
- Chlamydiosis.
- Campylobacter.
- Chlamydioidosis.
- Congenital Defects: Small Ruminants.
- Isolde Deficiency and Toxicity.
- Listeriosis.
- Neosporosis.
- Rift Valley Fever.
- Schmallenberg Virus.
- Selenium Toxicity.
- Toxoplasmosis: Cat population.

**Suggested Reading**


Author: Ahmed Tibary

Consulting Editor: Ahmed Tibary
**PATHOPHYSIOLOGY**

**Viral Abortion**
- Maternal infection occurs venaenterically, orally, via inhalation or across conjunctival mucosa.
- Vector transmission occurs with BTV (Culicoides spp.) and Cache Valley virus (multiple mosquitoes).
- Viruses replicate in local lymphoid tissue and spread hematogenously to secondary organs.
- Viruses invade the placenta hematogenously from the dam's systemic circulation and cause fetal infection.
- Fetal death occurs secondary to fetal infection and direct organ damage, or placental damage.
- Fetal expulsion can occur before or immediately after death, with expulsion of a fetus or live fetus. More commonly, a delay in fetal expulsion leads to autolysis. Fetal mummification may occur with some viral infections. In the bovine, fetal infection between 100 and 150 days leads to congenital neurologic abnormalities (BVDV; BTV, BPF).
- Fetal infection with noncytopathic BVDV strains between 1 and 3 months' gestation, usually 2 weeks to 3 months after maternal clinical disease, respiratory disease, fever, conjunctivitis, nasal discharge, small calves, persistently infected calves, congenital defects, fever, ocular and nasal discharge, oral ulcers, diarrhea, decreased milk production, epithelial erosions at the interdigital spaces, coronary bands, tears or vulva, hemorrhagic syndrome. BTV. Maternal ulcers in mouth, tongue, muzzle and coronary bands, coughing of hooves, abortion, stillbirth, hemorrhagic death, fetal malformations. BPF.

**Fungal Abortion**
- Fungi are thought to cause primary maternal respiratory or gastrointestinal disease and spread to placenta/neonate hematogenously. Fetal infection occurs by extension of amniotic fluid infection.
- **Nutritional Abortion**
  - Selenium deficiency 4–5% of aborted foetuses in a Canadian study.
- Fetal infection between 100 and 150 days of gestation leads to congenital neurologic abnormalities.

**GEOGRAPHIC DISTRIBUTION**

**PATHOBIOLOGY**

**Viral Abortion**
- Maternal illness and fever may develop before or immediately after death, with expulsion of a fetus or live fetus. More commonly, a delay in fetal expulsion leads to autolysis. Fetal mummification may occur with some viral infections. In the bovine, fetal infection between 100 and 150 days leads to congenital neurologic abnormalities (BVDV; BTV, BPF).
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**Surgical Considerations and Techniques**

**Medications**

** DRUG(S) OF CHOICE**

** Contraindications**

** Possible Interactions**

**Follow-up**

**Expected Course and Prognosis**

**Possible Complications**

**Client Education**

**Treatment**

**Therapeutic Approach**

**Abortion: Viral, Fungal, and Nutritional**

**CBC/Biochemistry/Urineysis**

**Other Laboratory Tests**

- Virus isolation from aborted tissues (lung, liver, spleen, kidney, adrenal glands, placenta).
- Virus isolation from maternal or maternal buffy coat (BVDV).
- Antigen detection (ELISA or IHC) or PCR on maternal or neonatal skin biopsies, serum, whole blood, milk, and nasal swabs (BVDV).
- Dam, fetal or pre-colonial calf serology (BVDV, RTV, BPV).

**Microscopic examination of skin or placental lesions** (fungal).

**Other Diagnostic Procedures**

- Fetal necropsy (see finding below).
- Determination of selenium content in fetal and maternal liver.

**Pathologic Findings**

- BHV-1: Autolytic fetus, pinpoint white foci of necrosis in liver, pulmonary and renal hemorrhage and necrosis, diffuse placentitis, and yellow/bronze amniotic fluid. • BVDV: Calves with congenital abnormalities (hydromcephaly, hydrocephalus, cerebral hypoplasia, microcephalalia, renal dysplasia, cataracts, thymic hypoplasia, hypothyroidism, brachygnathism, arthrogryposis, pulmonary or renal hypoplasia or dysplasia). Necrotizing myocarditis, hepatic congestion, ascites. Autolyzed fetuses with rarely recognizable lesions, typically necrotizing inflammation with mononuclear infiltrations and lymphoid depletion, and no placental lesions. • RTV: Congenital abnormalities (hydrencephaly; hydrocephalus). • Fungal: Minimal fetal autolysis with numerous epidermal plaques, emaciation, placentitis with severe thickening of cotyledons and intercotyledonary areas with a leathery appearance, cotyledons may contain attached necrotic cartilaginous tissue. • Selenium deficiency: Fetal ascites, cardiac dilation and nodular liver, myocardial necrosis and mineralization, necrosis of skeletal muscle.

**Imaging**

**Other Laboratory Tests**

- Fetal culture from aborted tissues (placenta, amniotic fluid, lung).
- Direct microscopic examination of skin or placental scrapings or histopathology (fungal).

**Other Diagnostic Procedures**

- Immunohistochemistry and/or immunofluorescence on fetal tissues (BHV-1, BVDV).
- PCR on aborted tissues (BHV-1, BVDV) or whole blood (RTV). • Gross lesions in fetal skin and placenta (fungal).
- Fungal culture from aborted tissues (placenta, amniotic fluid, lung).
- Direct microscopic examination of skin or placental scrapings or histopathology (fungal).

**Other Diagnostic Procedures**

- Fetal necropsy (see finding below).
- Determination of selenium content in fetal and maternal liver.

**Pathologic Findings**

- BHV-1: Autolytic fetus, pinpoint white foci of necrosis in liver, pulmonary and renal hemorrhage and necrosis, diffuse placentitis, and yellow/bronze amniotic fluid. • BVDV: Calves with congenital abnormalities (hydromcephaly, hydrocephalus, cerebral hypoplasia, microcephalalia, renal dysplasia, cataracts, thymic hypoplasia, hypothyroidism, brachygnathism, arthrogryposis, pulmonary or renal hypoplasia or dysplasia). Necrotizing myocarditis, hepatic congestion, ascites. Autolyzed fetuses with rarely recognizable lesions, typically necrotizing inflammation with mononuclear infiltrations and lymphoid depletion, and no placental lesions. • RTV: Congenital abnormalities (hydrencephaly; hydrocephalus). • Fungal: Minimal fetal autolysis with numerous epidermal plaques, emaciation, placentitis with severe thickening of cotyledons and intercotyledonary areas with a leathery appearance, cotyledons may contain attached necrotic cartilaginous tissue. • Selenium deficiency: Fetal ascites, cardiac dilation and nodular liver, myocardial necrosis and mineralization, necrosis of skeletal muscle.

**Treatment**

**Therapeutic Approach**

- Treatment of systemic disease, RFM, or metritis as needed. • Decrease environmental exposure to fungi by decreasing confinement and cow density, and improving ventilation and feed quality.

**Surgical Considerations and Techniques**

**Medications**

**DRUG(S) OF CHOICE**

**Contraindications**

**Possible Interactions**

**Follow-up**

**Expected Course and Prognosis**

**Possible Complications**

**Client Education**

**Treatment**

**Therapeutic Approach**

- Treatment of systemic disease, RFM, or metritis as needed. • Decrease environmental exposure to fungi by decreasing confinement and cow density, and improving ventilation and feed quality.
Actinobacillosis: Wooden Tongue

OVERVIEW
Actinobacillosis is caused by Actinobacillus ligniersii, a Gram-negative rod, usually in the oral cavity. It is commonly seen in cattle that come in contact with multiple sources of trauma, such as previous wounds or needle punctures. Abrasive feeds, crowded conditions, surgical lesions, and other sources of trauma may also contribute to the development of the disease.

DIFFERENTIAL DIAGNOSES
- Pharyngeal trauma and abscession
- Retropharyngeal lymphadenitis or lymphosarcoma
- Oral foreign bodies
- Dental disease
- Parasitic or foreign body granuloma
- Endocarditis or granulation tissue
- Contagious ehrlichiosis and caesius lymphadenitis in sheep and goats

PATHOLOGIC FINDINGS
- Firm, pale, gritty, granulomatous abscesses with multifocal necrotic foci containing mononuclear cells, neutrophils, eosinophils, and plant fibers. Microscopic examination of pus compressed between two glass slides shows “sulfur granule” or clublike rosette appearance with a central mass of Gram-negative rods.

DRUGS OF CHOICE
- Sodium iodide: 20% NaI, IV, once, or repeated at least once at 7–10-day intervals
- Organic iodides: 1 oz/450 kg PO daily following first IV administration above
- Antibiotics may be used alone or in conjunction with iodide treatment for severe cases

POSSIBLE INTERACTIONS
- Use of a soft feed will aid prehension during treatment
- Organic iodides: 1 oz/450 kg PO daily following first IV administration above
- Antibiotics may be used alone or in conjunction with iodide treatment for severe cases
- Use of a soft feed will aid prehension during treatment

MISCELLANEOUS
- Wooden tongue
- Woody tongue

ABBREVIATIONS
- IV: intravenous
- PO: per os
- Nal: sodium iodide

Differential diagnoses include pharyngeal trauma and abscession, retropharyngeal lymphadenitis or lymphosarcoma, oral foreign bodies, dental disease, parasitic or foreign body granuloma, endocarditis, or granulation tissue. Other causes include contagious ehrlichiosis, caesius lymphadenitis in sheep and goats. The pathologic findings include firm, pale, gritty, granulomatous abscesses with multifocal necrotic foci containing mononuclear cells, neutrophils, eosinophils, and plant fibers. Microscopic examination of pus compressed between two glass slides shows “sulfur granule” or clublike rosette appearance with a central mass of Gram-negative rods. Drugs of choice include sodium iodide (20% NaI, IV, once, or repeated at least once at 7–10-day intervals), organic iodides (1 oz/450 kg PO daily following first IV administration above), and antibiotics. Possible interactions include use of a soft feed to aid prehension during treatment and organic iodides (1 oz/450 kg PO daily following first IV administration above). Antibiotics may be used alone or in conjunction with iodide treatment for severe cases. Use of a soft feed will aid prehension during treatment.
SEE ALSO
- Caseous Lymphadenitis
- Oral Disorders
- Orf (Contagious Ecthyma)
- Tongue Trauma

Suggested Reading


Author Kaitlyn A. Lutz
Consulting Editor Christopher C.L. Chase
Acknowledgment The author and book editors acknowledge the prior contribution of David McKenzie.
**Actinomycosis: Lumpy Jaw**

**OVERVIEW**
Common, sporadic, chronic granulomatous osteomyelitis of cattle caused by non-spore-forming, Gram-positive, anaerobic bacterium *Actinomyces bovis*.

**CAUSES AND RISK FACTORS**
- Eruption of teeth in young cattle
- Rough feeds containing awns, foreign objects
- Procedures causing oral lacerations

**DIAGNOSIS**
- **DIFFERENTIAL DIAGNOSES**
  - Tooth root abscess
  - Osteomyelitis from cause other than *Actinomyces bovis*
  - Check abscesses from cause other than *Actinomyces bovis*
  - Movable, located in soft tissue
  - Impacted feed/foreign body between cheek and teeth

**PATHOLOGIC FINDINGS**
Osteomyelitis of the affected area; teeth may be involved. Important to differentiate from youth root abscess.

**IMAGING**
Microscopic examination of purulent debris: Microcolonies of *Actinomyces* in an osseous, amorphous matrix made of calcium phosphate (antigen-antibody complexes).

**MEDICATIONS**
- **DRUGS OF CHOICE**
  - Iodine therapy may cause abortion.
  - Sodium iodide: 70 mg/kg IV every 3 to 5 days until signs of iodism occur.

**TREATMENT**
Difficult to treat. Antibiotics and sodium iodide have been historically used. Surgical debridement and drainage may be necessary.

**DIFFERENTIAL DIAGNOSES**
- Tooth root abscess
- Osteomyelitis from cause other than *Actinomyces bovis*
- Check abscesses from cause other than *Actinomyces bovis*
- Movable, located in soft tissue
- Impacted feed/foreign body between cheek and teeth (soft, movable)

**IMAGING**
Microscopic examination of purulent debris: mix sample with saline and crush granules placed in anaerobic transport media.

**PATHOLOGIC FINDINGS**
Osteomyelitis with organisms present.

**EXPECTED COURSE AND PROGNOSIS**
If untreated, disease will progress until the tooth root abscess.

**POSSIBLE COMPLICATIONS**
- Some animals become distressed with iodine infusion (restlessness, dyspnea, tachycardia)
- Subcutaneous iodine causes severe irritation.

**PREVENTION**
- Avoid feed or procedures that could cause oral lacerations
- Monitor young cattle for swelling of mandible, especially following tooth eruptions
- Isolate cattle with discharging lesions
- There is no vaccine.

**PATIENT CARE**
- Lesions will slowly remodel after successful treatment. The affected areas may never return to normal.
- Recurrence is possible, even after prolonged periods of time.

**FOODS TO PREVENT**
- Feeds containing awns, foreign objects
- Procedures causing oral lacerations

**OTHER LABORATORY TESTS**
- Microscopic examination of purulent debris: mix sample with saline and crush granules placed in anaerobic transport media.

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**ABBREVIATION**
IV = intravenous

**SEE ALSO**
- Actinobacillosis: Wooden Tongue
- Caseous Lymphadenitis
- Oral Disorders
- Orf (Contagious Ecthyma)

**SUGGESTED READING**

**CONTRAINDICATIONS**
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- Avoid feed or procedures that could cause oral lacerations
- Monitor young cattle for swelling of mandible, especially following tooth eruptions
- Isolate cattle with discharging lesions
- There is no vaccine.
ACUPUNCTURE

DIAGNOSIS

OTHER DIAGNOSTIC PROCEDURES
A full Western veterinary physical examination should be performed prior to initiating treatment. Both the Western and TCVM examination results are taken together to formulate a diagnosis. Additional TCVM procedures which are not part of the traditional Western examination can include:

- Determination of the patient’s temperament type and element association.
- Inspection of the tongue: Tongue color, coating, and degree of moisture.
- Pulse diagnostic: Relative strength of the pulse at different points. In cattle, the pulse is taken at the coccygeal artery; in small ruminants the pulse is taken from the right and left carotid arteries, allowing for comparison between the two.
- Palpation along the meridians to find areas of sensitivity.

TREATMENT

THERAPEUTIC APPROACH

- Dry needle (DN): Insertion of sterile needles into an acupoint.
- Electroacupuncture (EA): Electrical stimulation of an acupoint; electrical leads are connected to the handles of the metal needles and either low or high frequency current sent into the points along with the associated channel. Provides greater, longer-lasting stimulation of a point or channel than dry needling alone.
- Aquapuncture (AA): Injection of sterile saline, vitamin B12, or the patient’s own blood into an acupuncture point. Provides longer-lasting stimulation of a given point than dry needling alone.
- Hemoaquupuncture (HA): Release of blood from an acupuncture point is pricked with a sterile hypodermic needle and allowed to bleed. Use to release excess heat or relieve stagnation.
- Moxibustion (mox): Sticks or cones of moxa are placed over an acupoint or along a meridian without insertion of a needle or other method of stimulation. Used to stimulate the point. Used to break up stagnation or warm the point.

Protocols
Treatment protocols should take into account the Western diagnosis, TCVM pattern diagnosis, patient’s temperament, and the owner’s primary concern for each individual case. As such there is no true “cookbook” protocol for any particular condition. That said, the most frequently used points for common Western medical diagnoses are given below with suggested techniques. For explanation of the channel names and point locations, see “Suggested Reading.” It is strongly recommended that one complete a formal training program prior to performing any acupuncture treatment.

- Dry needling alone.
- DN or AA; can be administered 2 hours prior to surgical procedures (e.g. castration, stabilization) for prevention.
- DN (GB-1), GV-14; DN for GV-14, HA for others: EA between GV-14 and Bai-hui.
- Hemorrhage: Duan-xue (GV-6), Tian-ting; DN or AA; can be administered 2 hours prior to surgical procedures (e.g. castration, stabilization) for prevention.
- Diarrhea: GV-1, ST-36, BL-20/21/25; DN or AA.

EXPECTED COURSE AND PROGNOSIS

- Infertility/subfertility: Bai-hui, Shen-ping, shu/jiao, Yan-chi, CV-1, DN, EA, or AA.
- Dystocia: SP-6, BL-60/67 to promote normal labor, add GB-21 for dystocia; DN or AA.
- Recuriaculation, esp. of reovac: GV-26, DN.
- Heat stress: Er-jian, Wei-jian, Tai-tang (GB-1), GV-14, DN for GV-14, HA for others; EA between GV-14 and Bai-hui.
- Hemorrhage: Duan-xue (GV-6), Tian-ting; DN or AA.
- Anestrus: Shan-gen (use hypodermic needle). Mi-jiao-gan, ST-36, DN.
- Calving paralysis: Bai-hui, GB-20/30, BL-54, GV-3 and KID-1; EA or AA.
- Heat stress: Er-jian, Wei-jian, Tai-tang (GB-1), GV-14, DN for GV-14, HA for others; EA between GV-14 and Bai-hui.

PRECAUTIONS
These medications have not been evaluated by the FDA and there are no established withdrawal times for any food-producing species.
POSSIBLE COMPLICATIONS

- Acupuncture should be used with caution during pregnancy. Avoid points around the abdomen, mid to lower back, and hips. Any points which move blood or Qi should be avoided, as well as potent points such as ST-36, LI-4, BL-67, and SP-6. The CV channel (along ventral midline) should not be stimulated during gestation.
- Very old or debilitated patients (See “Age-Related Factors”).
- Although extremely rare, needles can break off and become lodged in the muscle. To prevent breakage, use appropriately sized needles for each point, avoid using hypodermic needles except as a guide or for HA, and do not insert the needle completely up to the handle.
- Concurrent use of sedatives or demethaemoglobin will blunt the response to acupuncture and should be used only when necessary.

PATIENT CARE

- For complicated or severe conditions, multiple treatments over an extended period of time should be expected. As the primary condition improves, other symptoms and disease patterns may become more obvious and treatment protocols adjusted accordingly.

AGE-RELATED FACTORS

- Neonates and juvenile patients respond readily to acupuncture and may not need extensive treatment.
- Very old patients may not have enough energy or Qi left to tolerate a full acupuncture session. Since acupuncture moves energy around the body, it may deplete what little is left for these patients, leading to death. Short treatments with very few needles should be used.

PREGNANCY

- Acupuncture should be used with caution during pregnancy (see “Possible Complications”). Points which are both safe to use and can promote a healthy pregnancy include Bai-hui, Shen-peng/shu/jiao, and BL-20/21/32/23/24/25/26.

BIOSafety

- Acupuncture needles are single use only and should be disposed of properly in a sharps container.
- Use of blood for AA should only be performed with the patient’s own blood, injected immediately after being drawn from the jugular or ocçycal vein.

ABBREVIATIONS

- AA – acupuncture
- DN – dry needle technique
- EA – electroacupuncture
- HA – haemoacupuncture
- Moxa – moxibustion
- TCVM – Traditional Chinese Veterinary Medicine

See “Suggested Reading” for full explanation of acupuncture point abbreviations.

SEE ALSO

Alternative Medicine (see www.fiveminutevet.com/ruminant)

Suggested Reading


Internet Resources

- American Academy of Veterinary Acupuncture: http://www.aava.org/
- Association of British Veterinary Acupuncturists (training available): http://www.abva.co.uk/
- Association of Veterinary Acupuncturists of Canada: http://www.avcanada.org/
- Chi Institute (training available): http://www.tcvm.com/
- International Veterinary Acupuncture Society (training available): https://www.ivas.org/
- Online-SHM (training available): https://www.oneshithim.org/
- World Association of Traditional Chinese Veterinary Medicine: http://www.watzvm.org/

Author Christine M. Window
Consulting Editor Kaitlyn A. Lutz

Acknowledgment The Book Editors acknowledge the editorial contribution of Sharon Sherman in this topic.
**ACUTE RENAL FAILURE**

**BASICS**

**OVERVIEW**

Acute renal failure (ARF) is common in ruminants experiencing hemodynamic changes or exposed to nephrotoxins.

**PATHOPHYSIOLOGY**

- Dehydration, endotoxemia, hemolysis, and shock could result in ARF due to sustained decrease in renal perfusion (hyperperfusion and ischemia) and release of endogenous inflammatory and pressure mediators.
- Infarction of the renal cortex and destruction of the base membrane of tubular cells in cases of decreased renal perfusion results in nephron dysfunction.
- Direct injury to tubular cells caused by exposure to nephrotoxins.

**SIGNALMENT**

There is no predisposition of ruminant species, breed, sex, or age to develop ARF.

**CAUSES AND RISK FACTORS**

- Conditions that result in systemic compromise, dehydration, and hypertension such as diarrhea, septicemia, endotoxemia, disseminated intravascular coagulopathy, and acute blood loss. Nephrotoxic agents include heavy metals, aminoglycosides and tetracyclines, NSAIDs, toxic plants such as heavy metals, aminoglycosides and hyperemesis are common findings with ARF. Increased liver enzymes (SDH and GGT) values may be observed.

**SIGNLMENT**

There is no predisposition of ruminant species, breed, sex, or age to develop ARF. There is no predisposition of ruminant species, breed, sex, or age to develop ARF.

**PHYSICAL EXAMINATION FINDINGS**

- Signs of acute renal failure are nonspecific and signs of primary disease may mask renal affection. Anuria, oliguria, or polyuria may be observed.
- Affected animals may present with dehydration, depression, anorexia, and diarrhea.
- Oral ulcerations might be observed in ruminants. Severe cases develop muscular weakness and recumbency due to electrolyte and acid-base abnormalities.
- Rectal palpation in cattle may reveal left renal enlargement.

**DIFFERENTIAL DIAGNOSIS**

- Acute renal failure (ARF) is common in ruminants experiencing hemodynamic changes or exposed to nephrotoxins. Acute renal failure (ARF) is common in ruminants experiencing hemodynamic changes or exposed to nephrotoxins.

**PATHOLOGIC FINDINGS**

Renal tubular degeneration and necrosis is a consistent histopathologic finding.

**TREATMENT**

**THERAPEUTIC APPROACH**

- The animal should be removed from the source of the nephrotoxins or exposure discontinued.
- Isotonic, sodium-containing IV fluids with added calcium and potassium are indicated to correct acid-base and electrolyte abnormalities, increase renal perfusion, and promote diuresis. IV fluids should be administered until the serum creatinine has returned to normal (usually 2–3 weeks).
- Oral fluid therapy may be used if IV administration is impractical. IV or oral fluids should be administered at a rate of 60 mL/kg/day.
- Hydration and plasma protein should be monitored to avoid overhydration.
- Supportive care should include broad-spectrum antibiotics, serum transfusions, and nutritional support.

**DIAGNOSIS**

**DIFFERENTIAL DIAGNOSIS**

The nonspecific nature of clinical signs in cases of ARF in ruminants makes it difficult to develop a differential diagnosis list. Many primary disease conditions might result in ARF.

**CBC/BIOCHEMISTRY/URINALYSIS**

- Anemia (increased BUN and creatinine).
- Isosthenuria in the face of anuria is a strong indicator of ARF.
- Proteinuria, glucosuria, and granular casts may be present in urine. Metabolic alkalosis, hypochloremia, hypotension, hypocalcemia, hyperphosphatemia, and hyperkalemia are common findings with ARF. Increased liver enzymes (SDH and GGT) values may be observed.

**OTHER LABORATORY TESTS**

Fractional excretion of sodium may be evaluated but the test should be compared to a normal animal (e.g., herd mate) of similar age, physiologic state, and nutritional status.

**IMAGING**

Ultrasonographic evaluation may reveal loss of detail of cortico-medullary junction, dilation of renal pelves and perirenal edema.

**DIAGNOSTIC PROCEDURES**

- Glomerular filtration rate assessment provides precise information of renal function. Renal biopsy may provide diagnostic as well as prognostic information in cases of ARF.

**PATHOLOGIC FINDINGS**

Renal tubular degeneration and necrosis is a consistent histopathologic finding.

**TREATMENT**

**THERAPEUTIC APPROACH**

- The animal should be removed from the source of the nephrotoxins or exposure discontinued. Isotonic, sodium-containing IV fluids with added calcium and potassium are indicated to correct acid-base and electrolyte abnormalities, increase renal perfusion, and promote diuresis. IV fluids should be administered until the serum creatinine has returned to normal (usually 2–3 weeks). Oral fluid therapy may be used if IV administration is impractical. IV or oral fluids should be administered at a rate of 60 mL/kg/day. Hydration and plasma protein should be monitored to avoid overhydration. Supportive care should include broad-spectrum antibiotics, serum transfusions, and nutritional support.

**MEDICATIONS**

**DRUGS OF CHOICE**

- Furosemide (1 mg/kg IV or IM, q12h) administered every 2–3 hours to promote diuresis in anuric animals.
- A dopamine drip (2 μg/kg/min IV) should be considered if diuresis is not achieved.

**CONTRAINDICATIONS**

- With repeated use of furosemide, the patient’s serum sodium and potassium must be monitored carefully. Drug withdrawal times need to be determined and maintained in food-producing animals.

**EXPECTED COURSE AND PROGNOSIS**

- ARF due to ischemic episodes generally results in a grave prognosis. Renal failure due to toxic causes may have a more favorable prognosis.
- Failure to produce urine in the face of high volume IV fluids and diuretics carries a grave prognosis.

**ABBREVIATIONS**

- ARF = acute renal failure
- BUN = blood urea nitrogen
- GGT = gamma glutamyl transferase
- IM = intramuscular
- IV = intravenous
- NSAIDs = nonsteroidal anti-inflammatory drugs
- SDH = sorbitol dehydrogenase

**SEE ALSO**

- Diarrheal Disease: Bovine
- Diarrheal Diseases: Small Ruminants
- Oak (Quercus spp.) Toxicity
- Pyelonephritis

**Suggested Reading**


**Acknowledgment**

The author and book editors acknowledge the prior contribution of M.S. Gill.
Agricultural Chemical Toxicities

OVERVIEW

- Defined by the 1971 Agricultural Chemicals Regulation Law as "chemical agents such as fungicides and insecticides that are used to control crop-harming organisms (e.g., fungi, nematodes, mice, insects, and rodents) or viruses (hereinafter collectively referred to as 'pests')."
- Also included are plant growth regulators and germination inhibitors.
- EPA regulates pesticides in the USA; it must be properly disposed of, posing a hazard to ruminants.
- Residual agricultural chemicals are those remaining in the crops after application. They may become part of livestock feed and end up in meat or milk, harming ruminant animals (fetus and neonates in particular) and human beings.
- Agricultural chemicals are best classified by their specific application target.
- Fungicides—control fungi; includes oxiurids and lariurids.
- Insecticides—control insects that damage crops, field crops, and fruit trees.
- Herbicides—control weeds; may be selective for a specific plant or group of plants or be totally nonselective.
- Plant growth regulators—either inhibit or stimulate growth of crops.
- Attractants—attract insect pests.
- Repellants—repel birds and small mammals that may damage crops.
- Spreaders—substances mixed with other chemicals to enhance adherence.
- Rodenticides—control mice, rats, and other small rodents.
- Ruminants are exposed through ingestion of contaminated feeds, treated seeds, or stored chemicals as well as oral and dermal exposure to recently treated fields or pastures.
- Many banned or cancelled products such as arsenicals and organochlorines may not have been properly disposed of, posing a hazard to ruminants that may ingest them.
- Newer insecticides (i.e., pyrethrins and pyrethroids, fipronil, and neonicotinoids) are safer and have replaced organophosphate and carbamate, but they are not without some harm to animals and the environment.

PATHOPHYSIOLOGY

- Toxicity:
  - Variable depending on the product
  - Acute toxicity occurs within a few hours to a day.
  - Chronic toxicity develops over time and is much more difficult to diagnose.
  - Systemic absorption may result in accumulation in fat, liver, brain, kidney, and milk; some products result in transpulmonary transmission.
  - Insecticides: Older products
    - Organophosphate (OP) and carbamate compounds
      - OPs: diazinon, dichlorvos, malathion, parathion, others.
      - Carbamates: aldicarb, carbaryl, carbofuran, methomyl, others.
      - Inhibit the enzyme acetylcholinesterase at cholinergic junction.
      - Many are highly toxic and no longer registered in the USA; still widely used worldwide.
  - Insecticides: Newer products
    - Pyrethroids and pyrethridoids
      - Cyhalothrin, cypermethrin, deltamethrin, others.
      - Slow the opening of sodium channels resulting in hyperexcitability.
      - Most are highly lipophilic.
      - Generally safe.
      - Salivation, vomiting, tremors, seizures, dyspnea, prostration, death.
      - Generally safe unless exposed to highly concentrated product.
    - Buffalo and their calves may have increased risk of toxicity.
    - Neurotoxicity.
    - Methylmercury, thallium, selenium, arsenic, cadmium.
    - Inhibits GABA receptors, increases GABA neurotransmission.
    - Axonopathy, myelopathy, convulsions, death.
    - Methemoglobinemia, intravascular hemolysis.
  - Fungicides
    - Less acute toxicity; may be due to decreased oral absorption.
    - Highly toxic to ruminants.
    - Fever, dyspnea, tachycardia, seizures, death.
    - Methemoglobinemia, intravascular hemolysis.
    - Dimethoate compounds may cause yellow staining of the skin, conjunctiva, or hair.
    - Paraquat
    - Highly toxic when wet; very low toxicity once dry and bound to vegetation.
    - Restricted use, nonspecific herbicide that kills all vegetation.
    - Widespread worldwide, less so in USA.
    - Dipyridamone, amitriptyline, ataxia, salivation, recumbency, death.
    - Sodium chloride
    - Dystrophy, recumbency, seizures, abortion and infertilities.
    - Methemoglobinemia
    - Glycophosphate—considered less toxic, but controversial

HISTORICAL FINDINGS

- Toxic ingestion may be known or suspected based on thorough history taking.

SIGNALMENT

- Very young and old.
- Neonates without functioning rumens are at a greater risk of toxicity from pyrethroids, OPs, and carbamates.
- Buffalo calves may be more susceptible to fipronil and neonicotinoids (acetamiprid).

PHYSICAL EXAMINATION FINDINGS

- General nonspecific signs include:
  - Anorexia, myelopathy, decreased rumen motility and blood, abdominal pain, diarrhea (SLUDGE with OPs and carbamate insecticides).
  - Cardiac arrest
  - Bradycardia, ataxia, hyperexcitability, tremors, seizures, recumbency, coma
  - Tachypnea, dyspnea, respiratory arrest (parapneumonic)
  - Polyuria, anuria (paraquat)
  - Metheoglobinemia (chlorate and nitrate herbicides), cardiomyopathy
  - Hypothermia
  - Paralysis, myelopathy, intravascular hemolysis, dermatitis (pyrethroids).
  - Ophthalmic irritation (aerosolized products)
  - Ophthalmic irritation (aerosolized products)
  - Ophthalmic irritation (aerosolized products)
  - Ophthalmic irritation (aerosolized products)
  - Ophthalmic irritation (aerosolized products)
Blackwell’s Five-Minute Veterinary Consult

Agricultural Chemical Toxicities (Continued)

- See “Pathophysiology” for specific signs.
- Generally occur within 4–24 hours.
- May differ with individual animals, but specific system abnormalities are normally recognized in a herd situation.

CAUSES AND RISK FACTORS
- Improper storage or labeling of chemicals
- Equipment not cleaned well (e.g., ammonium nitrate residue in tank later used to fill water tanks)
- Access to a newly treated pasture or feed batch

DIAGNOSIS

DIFFERENTIAL DIAGNOSES
- Gastrointestinal—bloat, grain overload, coccidiosis
- Nervous—lead poisoning, nervous ketosis, polioencephalomalacia, rabies (single animal)
- Respiratory—bloat, infectious diseases

CBC/BIOCHEMISTRY/URINALYSIS
- Often unremarkable

OTHER LABORATORY TESTS
- Gas or liquid chromatography on fresh or frozen samples

OTHER DIAGNOSTIC PROCEDURES
- Variable
- Urine or milk analysis helpful for some exposures

PATHOLOGIC FINDINGS
- Often unremarkable; especially with sudden death

TREATMENT

THERAPEUTIC APPROACH
- Remove animals from suspected source.
- Activated charcoal or mineral oil within 10–12 hours of oral exposure
- Contraindicated: digestible oils such as corn oil may increase absorption and should not be used as a cathartic.

FOLLOW-UP

EXPECTED COURSE AND PROGNOSIS
- Specific agent and response to therapy guide prognosis.

POSSIBLE Complications
- Chronic poor production

PATIENT CARE
- Milk and meat testing for clearance time

PREVENTION
- Proper labeling and storage of chemicals
- Disposal of older products
- Effective cleaning of multiple use equipment

MISCELLANEOUS

AGE-RELATED FACTORS
- Pre-ruminants are more susceptible to chemicals degraded in the rumen.

ZOONOTIC POTENTIAL
- Meat and milk contamination
- Movement and/or marketing of animals poisoned with agricultural chemicals varies by state; consult with board of animal health or diagnostic laboratory

ABBREVIATIONS
- CNS = central nervous system
- DDIT = dichloro-diphenyl-trichloroethane
- EPA = Environmental Protection Agency
- OPs = organophosphorous insecticides
- SLUDGE = salivation, lacrimation, urination, diarrhea, gastroenteritis

Suggested Reading

Internet Resources

Acknowledgment
- The author and book editors acknowledge the prior contribution of Alejandro Ramirez.
AKABANE

OVERVIEW

Akabane virus (AKAV) is an arthropod-borne virus of ruminants. The virus is transmitted by small biting midges (or goats) of Calcocidius. Some species may carry both AKAV and bluetongue virus. AKAV infects a wide range of domesticated and wildlife ruminants. The disease has been reported in cattle, buffalo, sheep, and goats. Infection of pregnant animals results in abortion and stillbirth due to variable defects of the fetal nervous system and arthrogryposis, with no clinical signs in the dam.

INCIDENCE/PREVALENCE

In endemic areas, the disease has a seasonal pattern, with peak vector activity in summer and diagnosis of outbreak made the subsequent winter.

Most female animals are infected prior to reproductive age.

Disease is seen in naïve animals which become infected during pregnancy, either due to “spillover” of the vector from its region, or movement of naïve animals into endemic areas.

Surveys indicate that more than 80% of adult cattle in an endemic area are seropositive for AKAV. However, following years of drought or times of reduced vector populations, naïve livestock may not be exposed prior to breeding age and therefore become susceptible.

Data from Japanese and Australian outbreaks suggest that the fetus is infected in 30–40% of pregnant cows which are infected with AKAV.

GEOGRAPHIC DISTRIBUTION

The virus is widespread throughout Asia, Australia, Africa, and the Middle East. The virus is considered a foreign animal pathogen in the United States.

SYSTEMS AFFECTED

Reproductive
Musculoskeletal
Nervous

PATHOPHYSIOLOGY

AKAV is a single-stranded negative sense togavirus RNA virus. It is a member of the genus Orthobunyavirus, family Bunyaviridae, and serogroup Simbu. Four genotypes are identified (I, II, III, IV). After infection via the vector, the virus crosses the placenta and infects the fetus, leading to the clinical signs.

AKAV is a single-stranded negative sense RNA virus. It is a member of the genus Orthobunyavirus, family Bunyaviridae, and serogroup Simbu. Four genotypes are identified (I, II, III, IV).

Infection between days 79–104 of gestation results in hydroencephaly. Infection between days 105–174 results in arthrogryposis with Wallerian-type degeneration of the brain and spinal cord. Infection in late gestation can result in encephalomyelitis.

Infection in few postnatal calves and adult cows has been diagnosed in Japan, which manifested as encephalomyelitis.

In sheep, infection at approximately 40 days’ gestation resulted in fetal abnormalities.

In goats, infection at approximately 60 days’ gestation resulted in fetal abnormalities.

PHYSICAL EXAMINATION FINDINGS

Infections in adult ruminants are typically asymptomatic. However, the friki strain (Japan and Korea) has been associated with encephalitis.

The hallmark of AKAV is congenital abnormalities of the neurologic and muscular systems. Effects on the fetus depend on time of infection during gestation.

One group of investigators divided the gestational effects of AKAV into 5 groups (1 = early gestation infection; 5 = early gestation infection). Group 1 abnormalities included microscopic non-suppurative encephalomyelitis. Group 2 lesions included loss of ventral horn spinal cord neurons and Wallerian-type degeneration of ventral spinal nerves which resulted in ataxia, flaccid paralysis, and mild arthrogryposis. Group 4 lesions included arthrogryposis and hydroencephaly. Groups 3 and 5 were more severe manifestations of group 2 and 4 signs, respectively.

Dystocia may occur at parturition or abortion due to fetal abnormalities.

CAUSES AND RISK FACTORS

Clinical signs of AKAV are caused by exposure of ruminant fetuses to the virus by dam infection via Culicoides midges.

Outbreaks are related to seasonal factors and vector distribution.

Exposure of naïve pregnant animals to the virus-borne vector.

DIAGNOSIS

AKAV can be suspected based on clinical appearance of the fetus and knowledge of endemic areas; however, confirmation of the diagnosis by a diagnostic laboratory is required because gross appearance of AKAV is the same as many other vector-borne viruses.

DIFFERENTIAL DIAGNOSIS

Bluetongue virus
Bovine viral diarrhea virus
Bovine virus diarrhea virus
Schmallenberg virus
Cache Valley virus
Aino virus
Toxic, nutritional, or genetic causes of fetal neuromuscular defects

C CBC/BIOCHEMISTRY/URINALYSIS

N/A

OTHER LABORATORY TESTS

N/A

IMAGING

N/A

OTHER DIAGNOSTIC PROCEDURES

N/A

PATHOLOGIC FINDINGS

The most common lesions are arthrogryposis and hydroencephaly.

Other neurologic abnormalities may include hypertrophy and microencephaly.

In the brain, degenerative and necrotic neurons as well as perineuronal and perivascular edema has been described.

There may be loss of ventral horn spinal cord neurons and Wallerian-type degeneration of ventral spinal nerves.

Other findings in calves include gliosis, demyelination, hepatitis, nephritis, and myodegeneration/polymyositis.

In sheep, there can be a marked loss of the ventral horns of the spinal cord which leads to hypoplastic spinal cord and muscle atrophy (e.g., torticollis). Pulmonary hypoplasia may also be noted.
A

**AKABANE**

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**TREATMENT**

**THERAPEUTIC APPROACH**

- There is no treatment for AKAV.
- Most fetuses born alive die or are euthanized due to effects of the virus.
- Subsequent pregnancies of the dam will not be affected.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

N/A

**MEDICATIONS**

**DRUGS OF CHOICE**

N/A

**CONTRAINDICATIONS**

N/A

**PRECAUTIONS**

N/A

**POSSIBLE INTERACTIONS**

N/A

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**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**

- Most offspring born alive are either euthanized or die shortly after birth.
- Subsequent pregnancies of the dam will not be affected.

**POSSIBLE COMPLICATIONS**

- Dystocia
- Infertility

**CLIENT EDUCATION**

- In endemic areas, clients should be aware of repercussions of introducing naïve pregnant animals into the herd.
- Vaccination should also be considered in areas where it is available.

**PATIENT CARE**

- Specific treatment and supportive care if there are any complications following abortion.

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**PREVENTION**

- Prevention of AKAV includes vector control and vaccination.
- Vector control should include elimination of vector breeding sites, and repellents for pregnant animals.
- Naïve pregnant animals should not be introduced during seasons of high vector activity (summer and autumn).
- Naïve animals should be introduced to endemic areas prior to breeding to develop immunity.
- Breeding season may be altered to avoid period of highest risk.
- Live (Japan) and inactivated (Japan, Australia, Korea) vaccines are available for the prevention of AKAV and are to be administered prior to breeding.

**MISCELLANEOUS**

**ASSOCIATED CONDITIONS**

Dystocia, retained placenta

**AGE-RELATED FACTORS**

AKAV affects fetal ruminants.

**ZOONOTIC POTENTIAL**

There are no indications that AKAV is zoonotic.

**PREGNANCY**

**Effects of AKAV** are dependent on the gestational age of the fetus at the time of infection. However, most affected neonates die or are euthanized after birth due to effects of the virus irrespective of time of infection in utero.

**BIOSECURITY**

Suspected cases or outbreaks of AKAV outside its endemic areas (see “Geographic Distribution”) should immediately be reported to the proper governmental veterinary authorities (i.e., state or federal veterinarians).

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**PRODUCTION MANAGEMENT**

- In endemic areas, avoid introduction of naïve pregnant animals in the summer and autumn months.
- Implement vector control programs to reduce potential transmission of AKAV.
- Consider vaccination protocols prior to breeding.

**SYNONYM**

Arthrogryposis-hydram drain syndrome (AH syndrome)

**ABBREVIATION**

AKAV = Akabane virus

**SEE ALSO**

- Abortion: Viral, Fungal, and Nutritional
- Arthrogryposis
- Bluetongue Virus
- Border Disease
- Bovine Viral Diarrhea Virus
- Cache Valley Virus
- Congenital Defects: Bovine
- Lupine Toxicity
- Schmallenberg Virus

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**Suggested Reading**


Author: Lisa Pearson

Consulting Editor: Ahmed Tibary

Acknowledgment: The author and book editors acknowledge the prior contribution of Glenda Dvorak.
CAUSES AND RISK FACTORS
Common agents causing anaphylaxis include blood transfusions, vaccines, horse sera, insect bites, heterologous enzymes and hormones, and certain drugs, such as penicillin and lidocaine. Milk allergy occurs occasionally in cows. This can happen when there is increased intramammary pressure to a point that normally sequestered milk components, notably casein, gain access to the circulation; these “foreign” proteins induce a type I hypersensitivity. Previous exposure to antigens (i.e., previous treatment with blood or blood products or vaccines).

Differential Diagnoses
- Acute Bloat
- Acute Bronchopneumonia

CBC/Biochemistry/Urinalysis
Increase in PCV, high plasma K⁺, neutropenia

PATHOPHYSIOLOGY
Anaphylaxis is an acute systemic manifestation of the interaction of an antigen (allergen) binding to IgE antibodies, which are bound to mast cells and basophils. This binding of antigens to cell-bound IgE antibodies triggers the release of chemical substances from the mast cells and basophils. These chemicals directly affect both the vascular system, causing vasodilation and increased vascular permeability, and smooth muscles, causing contraction of the bronchi and respiratory distress.

SYSTEMS AFFECTED
- Cardiovascular
- Respiratory
- Urinary
- Integument

DIFFERENTIAL DIAGNOSES
- Acute Bloat
- Acute Bronchopneumonia

CBC/BIOCHEMISTRY/URINALYSIS
Increase in PCV, high plasma K⁺, neutropenia

PATHOLOGIC FINDINGS
Lungs—severe pulmonary edema in calves and lambs; pulmonary edema and emphysema without blood engorgement.

THERAPEUTIC APPROACH
- Ancillary support of blood pressure (IV fluids) and respiration may be necessary.
- Antihistamines have no effect once signs are present.
- Corticosteroids potentiate the effects of antihistamines.

Ancillary Support of Blood Pressure
- fluids (crystalloids and colloids)
- Packed cell volume

DRUGS OF CHOICE
- Medetomidine
- Alfaxalone

TREATMENT
- Anaphylactic shock is treated with an injection of epinephrine. Epinephrine (1/100) subcutaneously or intravenously at a dose of 1 ml per 100 lb. of body weight is the drug of choice and can literally be a lifesaver. A second dose can be given in 15–20 minutes if needed. *In addition, furosemide (0.5 mg/kg) may be given.*
- Corticosteroids potentiate the effects of epinephrine and may be given following the administration of epinephrine.
- Antihistamines have no effect once signs are present.

Follow-up
- Expected course and prognosis
  Animals treated promptly usually return to normal within 12–24 h.

Possible Complications
- Respiratory distress
- Cardiac arrest
- Shock and often vascular collapse

PATIENT CARE
Animals need to have their respiratory system monitored for the next 24 h to detect any emphysema.

PREVENTION
Discuss the situation associated with the onset with the producer. Certain products may need to be avoided.

MISCELLANEOUS
ABBREVIATIONS
- IgE = immunoglobulin E
- IV = intravenous
- PCV = packed cell volume

SEE ALSO
- Bloat
- Plants Producing Acute Respiratory Distress Syndrome
- Respiratory Disease: Bovine

Suggested Reading

Author: Christopher C. L. Chase
Consulting Editor: Christopher C. L. Chase
### ANAPLASMOSIS

#### BASICS

**OVERVIEW**

*Anaplasma* is a hemoparasite of ruminants.

**INCIDENCE/PREVALENCE**

Anaplasmosis is the most prevalent tickborne disease of cattle.

**GEOGRAPHIC DISTRIBUTION**

Worldwide.

**PATHOPHYSIOLOGY**

- *Anaplasma marginale* is the most common cause of clinical disease in cattle; *A. centrale* causes mild disease.
- *A. ovis* causes mild disease in sheep.
- *Anaplasma* is transmitted by many ticks including *Dermacentor* (USA) and *Rhipicephalus* spp. (other regions).
- Iatrogenic transmission can occur.

**TRANSMISSION**

- Outbreaks.
- Animals to non-endemic areas may precipitate naive adults to endemic areas or carrier states.
- Infected animals may remain subclinical carriers.

**CLINICAL DISEASE**

- Cattle over 3 years of age are more likely to be infected, and deaths are more common in cattle over 6 months to 3 years of age.
- Clinical disease primarily occurs in cattle over 3 years.
- Anemia results in tachypnea, tachycardia, pallor, icterus, exercise intolerance, ataxia, and death.
- Hemoglobinemia and hemoglobinuria.
- Increased hepatobiliary values.
- No hemoglobinemia or hemoglobinuria in sheep.
- Hemolytic anemia.
- Significant signs of anemia and low PCV.

**PATHOLOGICAL FINDINGS**

- Pallor or icterus
- Splenomegaly
- Hepatomegaly
- Prominent erythrophagocytosis in reticuloendothelial organs

#### TREATMENT

**THERAPEUTIC APPROACH**

- Minimize stress
- Blood transfusion if significant signs of anemia and low PCV

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

N/A

**MEDICATIONS**

**DRUGS OF CHOICE**

- Long-acting oxytetracycline 20 mg/kg, IM or SQ, once to twice q 72 h.
- Imidocarb - competitive ELISA

**PRECAUTIONS**

- Appropriate milk and meat withdrawal times are followed for all pharmaceutical agents administered to food-producing animals.

**POSSIBLE INTERACTIONS**

- Blood transfusion is required.

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**

- Mildly affected animals may recover and become carriers.
- Severely affected animals often die within hours to days.

**POSSIBLE COMPLICATIONS**

- Old protocols to clear the carrier state are ineffective.
- New carrier state protocols violate AMDUCA.
- Clearing carrier animals makes them susceptible to reinfection.

### CLIENT EDUCATION

**N/A**

**PREGNANCY**

Abortion can occur.

**AGE-RELATED FACTORS**

- Can cause significant loss in endemic areas.

**SYNONYMS**

N/A

**ABBREVIATIONS**

- cELISA = competitive ELISA

**SEE ALSO**

- Babesiosis
- Bacillary Hemoglobinuria
- Leptospirosis

**SUGGESTED READING**


**AUTHOR**

Dusty W. Nagy

**CONSULTING EDITOR**

Erica C. McKenzie
Anemia, Nonregenerative

BASICS

OVERVIEW
- Anemia is defined as a decrease in the red blood cell (RBC) count, hemoglobin (Hb) concentration, and/or packed cell volume (PCV).
- Nonregenerative anemia is caused by reduced or defective erythropoiesis.
- Nonregenerative anemia is suspected when signs of bone marrow regeneration (reticulocytosis, polychromasia, and basophilic stippling of RBCs) are minimal to absent.

SYSTEMS AFFECTED
- Multisystem

PATHOPHYSIOLOGY
- Anemia is characterized by a reduced capacity of the blood to transport oxygen, leading to systemic tissue hypoxia and increased erythropoietin (EPO) production.
- Most clinical signs associated with anemia result from poor tissue oxygen delivery.

Nonregenerative Anemia Caused by Reduced Erythropoiesis
- Chronic inflammation, chronic renal disease, or bone marrow failure can lead to reduced erythropoiesis.
- Chronic inflammation is associated with increased liver expression of hepcidin, liver, causing alterations in iron metabolism and bone marrow responsiveness to EPO.
- Chronic renal disease can be associated with decreased EPO production by the kidneys.
- Destruction of hematopoietic stem cells due to damage by toxins, infections, immune-mediated mechanisms, or infiltration of the marrow with abnormal cells can lead to bone marrow failure.

Nonregenerative Anemia Caused by Defective Erythropoiesis
- Disorders of Hb or DNA synthesis can lead to defective erythropoiesis.
- Iron (Fe) and copper (Cu) deficiencies can impair Hb synthesis.
- Iron is crucial to Hb synthesis because each Hb molecule is made up of four heme groups, each group being composed of an Fe molecule and a porphyrin.

Gross
- Iron deficiency is usually caused by chronic blood loss but can also be secondary to dietary Fe deficiency in young milk-fed animals.
- Copper deficiency can lead to Fe deficiency because several Cu-containing proteins are required for Fe transport.
- Dietary Cu deficiency and/or excessive dietary intake of molybdenum, sulfate, or zinc can cause decreased Cu absorption and lead to Fe deficiency.
- Dietary cobalt (Co) deficiency can cause Co deficiency and lead to vitamin B12 deficiency and defective DNA synthesis.

HISTORICAL FINDINGS
- Weakness, lethargy, anorexia, weight loss, exercise intolerance, or syncope.

SIGNALMENT
- Bovine, ovine, caprine, and camelid species.

PHYSICAL EXAMINATION FINDINGS
- Clinical signs are less overt when the anemia progresses slowly.
- Lethargy, weakness, or obtundation.
- Pale mucous membranes.
- Heart murmur (due to reduced blood viscosity).

GENETICS
- Congenital dyserythropoiesis is an autosomal recessive trait in polled Hereford cattle.
- Myelofibrosis is an autosomal recessive trait in pygmy goats.

CAUSES AND RISK FACTORS

Nonregenerative Anemia Caused by Reduced Erythropoiesis
- Common causes of chronic inflammation include pneumonia, peritonitis, deep digital sepsis, liver abscesses, parabasallosis, and lymphosarcoma.
- Causes of chronic renal disease include pyelonephritis, urolithiasis, amyloidosis, and glomerulonephritis.
- Causes of bone marrow failure include bracken fern toxicosis, bovine neonatal parvovirus, irradiation, myelofibrosis, and neoplasia.

Nonregenerative Anemia Caused by Defective Erythropoiesis
- Causes of defective erythropoiesis include congenital dyserythropoiesis and deficiencies in Fe, Cu, and Co.

DIAGNOSIS

DIFFERENTIAL DIAGNOSIS
- Nonspecific, normochromic anemia with normal to increased neutrophil and platelet counts can be caused by chronic inflammation or renal disease.
- Nonspecific, normochromic anemia with decreased neutrophil and/or platelet counts can be caused by bone marrow failure.
- Macrocytic, hypochromic anemia with variable neutrophil and platelet counts can be caused by iron or copper deficiencies.
- Macrocytic, normochromic anemia with variable neutrophil and platelet counts can be caused by cobalt deficiency or congenital dyserythropoiesis.

CBC/BIOCHEMISTRY/URINALYSIS
- The PCV is the easiest and most accurate method to identify anemia.
- The PCV should be interpreted with consideration of the animal’s hydration status and any potential cause of plenic contraction (excitation, exercise, handling, or transportation).

Severity of anemia PCV (%)
- Mild 20–26
- Moderate 14–19
- Severe 10–13
- Very severe <10

- Blood should be analyzed within 30–60 minutes of collection or stored at refrigerator temperature (4°C) and analyzed within 24 hours.
- Delayed analysis may result in marked cellular swelling and therefore a false increase in MCV.
- Hypochromasia and microcytosis are hallmarks of iron and copper deficiencies.
- Hyperbilirubinemia, hypalbuminemia, and hypergлюбulinemia are often present in animals with chronic inflammation.

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A chronic inflammatory or renal disease

Differential diagnoses

Nonregenerative anemia with normal to increased neutrophil and platelet counts can be caused by chronic inflammation or renal disease.

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Numerous conditions can cause nonregenerative anemia. Common causes include chronic renal disease, cancer, chronic infections, and parasitism. Chronic inflammation and iron deficiency are frequent causes of nonregenerative anemia. Other causes of nonregenerative anemia are iron deficiency, copper deficiency, cobalt deficiency, and parasitism.

**OTHER LABORATORY TESTS**

### Chronic Inflammation and Iron Deficiency

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<th>Normal (N)</th>
<th>Decreased (↓)</th>
<th>Increased (↑)</th>
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<td>Serum ferritin</td>
<td>N</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Bone marrow</td>
<td>N</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Iron content</td>
<td>N</td>
<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Total iron binding capacity</td>
<td>N</td>
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* N = normal, ↓ = decreased, and ↑ = increased

### Copper Deficiency

- Plasma Cu concentration: <0.5 μg/mL
- Hepatic Cu concentration: <35 ppm on a dry matter basis

### Cobalt Deficiency

- Serum vitamin B12 concentration: <0.2 mg/mL
- Hepatic vitamin B12 concentration: <0.2 ppm (dry matter basis)

### Parasitism

- Examination of the skin and coat
- Fecal flotation

**OTHER DIAGNOSTIC PROCEDURES**

- Bone marrow examination is indicated when the cause of a nonregenerative anemia remains undetermined and/or atypical or unexplained immature cells are observed on the peripheral blood smear.

**TREATMENT**

### Therapeutic Approach

- Treatment must primarily address the underlying cause(s) of the anemia.
- Blood transfusion is indicated in valuable animals with overt clinical signs of anemia and/or PCV <12%.
- Activity and stress should be minimized.
- Routine care procedures should be delayed (deworming, hoof trimming...).

### MEDICATIONS

#### Drugs of Choice

- Oral iron supplementation is indicated with iron deficiency anemia.
- Oxygen therapy may be beneficial in hypoxemic animals (PaO2 <80 mmHg).

#### Contraindications

- Iron supplementation is contraindicated in animals with chronic inflammation.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

### Follow-up

#### Expected Course and Prognosis

- Clinical course and prognosis is dependent on the underlying disease process.
- Reevaluation is indicated after 7–10 days in stabilized animals.

### Patient Care

- Heart rate, respiratory rate, mucous membrane color, blood lactate, and arterial blood gas analysis can be used to monitor systemic tissue oxygen delivery.
- CBC or PCV with blood smear examination should be repeated every 1–2 days until evidence of bone marrow regeneration is present.
- Reticulocyte is indicated after 7–10 days in stabilized animals.

### Prevention

- Feeding of trace mineral supplements with label claims for the species that are being supplemented is recommended.
- Diet should contain 4–10 ppm of Cu, 0.1–0.2 ppm of Co, and 30–40 ppm of Fe.
- The dietary copper/molybdenum ratio should be maintained between 5:1 and 10:1.

### Miscellaneous

#### Associated Conditions

- A congenital syndrome characterized by dyserythropoiesis and progressive alopecia has been described in polled Hereford cattle.

#### Age-Related Factors

N/A

#### Synonyms

- Anemia of inflammatory disease

#### Abbreviations

- CBC = complete blood count
- Co = cobalt
- Cu = copper
- DNA = deoxyribonucleic acid
- EPO = erythropoietin
- Fe = iron
- Hb = hemoglobin
- MCHC = mean corpuscular hemoglobin concentration
- MCV = mean corpuscular volume
- PaO2 = partial pressure of oxygen in arterial blood
- PCV = packed cell volume
- RBC = red blood cell

#### See Also

- Anemia, Regenerative
- Bracken Fern Toxicity
- Copper Deficiency and Toxicity
- Molybdenum Toxicity
- Parasite Control Programs

**Suggested Reading**


**Author**

Thibaud Kuca

**Consulting Editor**

Christopher C.L. Chase
**Overview**

Anemia is defined as a decrease in the red blood cell (RBC) count, hemoglobin (Hb) concentration, and/or packed cell volume (PCV).

**Regenerative anemia** is caused by blood loss and/or accelerated RBC destruction.

- Extravascular hemolysis is more common than intravascular hemolysis.
- Chronic copper toxicosis occurs most commonly in sheep.
- Neutrophil isosyncytosis (NI) has been described in calves born to cows immunized with Ascaris or Babesia vaccines.
- NI has been described in lambs and kids following ingestion of bovine colostrum.

**Systems Affected**

- **Intravascular hemolysis** can occur within the blood vessels (extravascular) or outside of the blood vessels (intravascular).
- Extravascular hemolytic anemia is more common than intravascular hemolytic anemia.
- Reticulocyte counts are usually higher in hemolytic anemias than in hemorrhagic anemias.
- The onset of clinical signs is usually paroxysmal.

**Incidence/Prevalence**

- Extravascular hemolysis is more common than intravascular hemolysis.
- Thrombocytopenia is usually higher in hemolytic anemias than in hemorrhagic anemias.
- Polychromasia and basophilic stippling of RBCs.
- Anemia is characterized by a reduced capacity of the blood to transport oxygen, increased erythropoietin production, and/or increased MCHC.

**Basics**

**Pathophysiology**

- Anemia is characterized by a reduced capacity of the blood to transport oxygen, leading to systemic tissue hypoxia and increased erythropoietin production.
- Extravascular hemolysis usually occurs peracute to acute with intravascular hemolysis.
- Hemoglobinuria can develop if the plasma free Hb concentration exceeds the capacity of renal tubular reabsorption.
- Causes of intravascular hemolysis include bacterial infections, erythrocytic parasites, oxidative damage to the RBC membrane, primary immune-mediated disorders, osmotic lysis, envenomation, and congenital disorders.
- Extravascular hemolysis results from sequestration and phagocytosis of RBCs in splen or liver due to decreased RBC deformability or immune-mediated mechanisms.
- Extravascular hemolysis does not cause hemoglobinemia or hemoglobinuria.
- Causes of extravascular hemolytic anemias include erythrophagocytosis and endothelial parasites and congenital disorders.

**Signalment**

- Bovine, ovine, caprine, and camelid species.
- Neonatal isosyncytosis (NI) can occur in calves born to cows immunized with Anaplasma or Babesia vaccines and in lambs fed bovine colostrum.
- Chronic copper (Cu) toxicosis occurs most commonly in sheep.
- Hereditary factor VII and IX deficiencies almost always occur in males.
- Anaplasmosis and babesiosis occur more commonly in adults.

**Physical Examination Findings**

- Leukopenia, neutropenia, weakness, or syncope.
- Pale mucous membranes.
- Tachycardia and tachypnea.
- Pale or icteric mucus membranes.
- Tachycardia and tachypnea.
- Heat murmur due to reduced blood viscosity.

**Genetics**

- Hereditary factor VIII deficiency is an autosomal recessive trait in Hereford and Japanese Brown cattle.
- Hereditary factor XI deficiency is an autosomal recessive trait in Holstein and Japanese Black cattle.
- Hereditary albinogenemia is an incompletely dominant trait in Brown TVs.
- Hereditary phlyctenuyposis is an autosomal dominant trait in Japanese Black cattle.
- Congenital erythropoietic porphyria is an autosomal recessive trait in Holstein cattle.

**Causes and Risk Factors**

**Regenerative Anemia Caused by Acute Blood Loss**

- Coagulation factor deficiencies.
- Disseminated intravascular coagulation (DIC).
- Hereditary albinogenemia and factor VIII or XI deficiencies.
- Moldy sweet clover and toadsticle toxicosis.
- Gastrointestinal ulcers.
- Hemolytic bowel syndrome.

**Regenerative Anemia Caused by Chronic Blood Loss**

- Gastrointestinal ulcers.
- Chronic hematuria.
- Blacken fern toxicosis + Urolochia.
- Pyelonephritis.
- Hereditary albinogenemia and factor VIII or XI deficiencies.
- Parasites.
- Internal (Haemonchus spp., Barboura spp., Eimeria spp.) + External (blood sucking lice, flies, ticks).

**Regenerative Anemia Caused by Accelerated RBC Destruction**

**Causes of Extravascular Hemolysis**

- Intravascular parasitic causes.
- Erythrocytic parasitic causes.
- Candidatus Mycoplasma haemolamae in camels + Mycoplasma ovipneumoniae in cattle and M. ovis in small ruminants.
- Extravascular parasitic causes.
- Trypanosoma evaginatum, T. brucei, and T. vivax in cattle.
- Endothelial parasitic causes.
- Leucocytozoon spp. in cattle, and small ruminants.
- Hereditary RBC membrane defects.
- Hereditary phlyctenuyposis.

**Causes of Intravascular Hemolysis**

- Bovine diarrhea virus infection.
- DIC + Snake envenomation.
- Trauma.

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CBC/BIOCHEMISTRY/URINALYSIS
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**Hemolysis**

**Intravascular versus Extravascular**

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<tr>
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<td>N - ↑</td>
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| aPTT = activated partial thromboplastin time, PT = prothrombin time, TT = thrombin time, N = normal, and ↑ = increased |

**Pathologic Findings**

- Extravascular hemolysis is usually associated with splenomegaly.

**TREATMENT**

**MEDICATIONS**

**DRUGS OF CHOICE**

- Oral iron supplementation is indicated with chronic blood loss. • Oxygen therapy may be beneficial in hypoxemic animals (Pao2, <80 mmHg). • Fluid therapy is indicated with hypovolemia to support cardiovascular function and with intravascular hemolysis to prevent renal damage.

**CONTRAINDICATIONS**

- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**

- Clinical course and prognosis is dependent on the underlying disease process. • Return to reference intervals is expected in 1–2 weeks following a single acute blood loss. • Chronic blood loss should be suspected if reticulocyte counts persist >3 weeks.

**POSSIBLE COMPLICATIONS**

- Iron deficiency anemia loss develops more quickly in young milk-fed animals because they have limited Fe stores.

**PATIENT CARE**

- Heart rate, respiratory rate, mucous membrane color, blood lactate, and arterial blood gas analysis can be used to monitor systemic tissue oxygen delivery. • CBC or PCV with blood smear examination should be delayed (deworming, hoof trimming ...).
(CONTINUED) Anemia, Regenerative

Anemia, Regenerative

be repeated every 1–2 days until stabilization of the PVC. Reevaluation is indicated after 7–10 days in stabilized animals.

PREVENTION

- Cross-matching is indicated in animals receiving more than one blood transfusion.
- Feeding of trace mineral supplements with label claims for the species that are being supplemented is recommended. Diet should contain 6–10 ppm of Cu and not less than 0.1 ppm of Se. The dietary copper/molybdenum ratio should be maintained between 5:1 and 10:1.
- Prevention programs of vector-borne diseases should be implemented in endemic areas.

MISCELLANEOUS

ABBREVIATIONS

- aPTT = activated partial thromboplastin time
- CBC = complete blood count
- Cu = copper
- DIC = disseminated intravascular coagulation
- Fe = iron
- G6PD = glucose-6-phosphate dehydrogenase
- Hb = hemoglobin
- MCHC = mean corpuscular hemoglobin concentration
- MCV = mean corpuscular volume
- NI = neonatal isoerythrolysis
- PaO2 = partial pressure of oxygen in arterial blood
- PCV = packed cell volume
- PT = prothrombin time
- RBC = red blood cell
- Se = selenium
- TT = thrombin time

SEE ALSO

- Anaplasmosis
- Anemia, Nonregenerative
- Babesiosis
- Bracken Fern Toxicity
- Brassica spp. Toxicity
- Copper Deficiency and Toxicity
- Haemonchosis
- Parasite Control Programs
- Parasitic Skin Diseases
- Rodenticide Toxicity
- Selenium Deficiency
- Sweet Clover Poisoning
- Trypanosomiasis
- Zinc Deficiency and Toxicity

Suggested Reading


Author Thibaud Kuca
Consulting Editor Christopher C.L. Chase
**Anesthesia: Inhalation**

**Overview**
- Most ruminants tolerate surgical procedures with appropriate physical restraint, local or regional anesthesia, and sedation (if necessary).
- Inhalational anesthesia requires specialized equipment including: an anesthetic machine, oxygen source, oxygen regulator, oxygen flow meter, agent-specific vaporizer, breathing circuit, and a gas scavenging system.
- Ruminants <60 kg can be anesthetized with a conventional small animal machine. Ruminants >250 kg should be anesthetized with a conventional large animal anesthetic machine.
- Endotracheal intubation and proper cuff inflation are recommended.
- Inhalational anesthetics do not provide analgesia.
- Inhalant anesthetics are off-label drugs in food-producing animals. These agents are contraindicated in small animals.

**System Affected**
- Nervous
- Musculoskeletal
- Respiratory
- Cardiovascular

**Pathophysiology**
- General anesthesia is defined as a state of unconsciousness from which the patient can be aroused by physical means as opposed to stimulation of the CNS not arousable by noxious stimuli. The sensory, motor, and autonomic functions of the body are attenuated to different degrees based on type of drugs used and the dose administered.
- Inhalant anesthetics are administered and removed primarily through the lungs.
- The mechanism of inhalant anesthesia actions is still largely unknown.

**Minimum Alveolar Concentration (MAC)**
- Inhalant anesthetic doses are based on the calculation of MAC in healthy animals anesthetized without other drugs (Table 1).
- MAC is the minimum alveolar concentration of inhalant anesthetic that produces immobility in 50% of patients from responding to a suprathreshold stimulus (electrical stimulation of oral mucus membrane). This is equivalent to the ED<sub>50</sub> and corresponds to a light plane of anesthesia.
- The ED<sub>50</sub> is equal to 1.2 to 1.4 x MAC<sub>100</sub> and corresponds to a moderate plane anesthetic in 95% of patients.
- There is some individual variation in MAC and inhalant dose should be titrated based on the patient's. The patient's monitored anesthetic depth and physiologic parameters.
- If adjunctive anesthetics or analgesics are used, the MAC requirements may be reduced, therefor the inhalant dose should be titrated based on what stated above.

**Signalment**
- Following all ruminant species

**Physical Examination Findings**
- Palpebral reflexes disappear at minimal anesthetic depth in ruminants but corneal reflexes remain intact.
- Cattle demonstrate eye globe rotation at different depths of anesthesia. When awake, the globe is positioned between the eyelids. At induction, the globe rotates ventrally and may be partially hidden below the lower eyelid. As anesthetic depth increases, the globe can be completely hidden under the lower eyelid. At the surgical anesthetic plane, the globe rotates dorsally between the eyelids again.
- Any purposeful movement will indicate an increase in anesthetic depth and physiologic parameters.

**Drugs of Choice**

<table>
<thead>
<tr>
<th>Species</th>
<th>Isoflurane</th>
<th>Sevoflurane</th>
<th>Halothane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow</td>
<td>1.14</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>1.58</td>
<td></td>
<td>0.97</td>
</tr>
<tr>
<td>Goat</td>
<td>1.2–1.5</td>
<td>2.33</td>
<td>1.29–1.3</td>
</tr>
</tbody>
</table>

**Diagnosis**

**CBC/Biochemistry/Urine Analysis**
- May be included as routine preoperative workup.
- Recommended for sick patients with an ASA status of III or higher.

**Other Laboratory Testing**

- Blood gas analysis (arterial or venous) if suspect respiratory disease or patient is not appropriately fasted.

**Treatment**

**Drug of Choice**

- Isoflurane
  - The most common anesthetic agent used today.
  - Isoflurane is less arrhythmogenic than halothane and is not dependent on metabolism for elimination.

- Sevoflurane
  - Currently widely available but not used in food animal anesthesia, often due to cost.
  - Sevoflurane is less arrhythmogenic than halothane and is not dependent on metabolism for elimination.

- Halothane
  - Limited availability but may still be available in some areas.
• Halothane is associated with increased risk of cardiac arrhythmias in patients with high amounts of circulating catecholamines (i.e., stressed animals, septic shock).

• A preservative, thymol, is added to the halothane to prevent degradation. Thymol can concentrate within a vaporizer over time so frequent cleaning is recommended.

CONTRAINDICATIONS
• Caution in non-fasted animals.
• Caution in patients with compromised airways, respiratory systems, or systemic hypotension.

PRECAUTIONS
Meat and milk withholding: No current published withholding times. Suggested withholding times may be obtained by contacting FARAD.

POSSIBLE INTERACTIONS
N/A

FOLLOW-UP

CLIENT EDUCATION
Discuss the risks associated with general anesthesia with clients prior to performing on the client’s animal(s).

PATIENT CARE
• Ruminants tend to hypoventilate under general anesthesia and require mechanical ventilation for procedures >90 minutes or if hypercapnic and/or hypoxemic.
• Other potential complications include: tachycardia, hypotension, hypothermia, and hypoventilation. Monitoring for these complications is important, especially in compromised patients, and can be assisted by use of EKG, blood pressure monitoring, thermometer, and arterial blood gas analysis when available.

Suggested Reading


Author Jennifer L Bornkamp
Consulting Editor Kaelyn A. Lutz
**Anesthesia: Injectable**

### Basics

**Overview**
- General anesthesia produces unconsciousness, analgesia, and muscle relaxation for surgical or diagnostic procedures.
- To prevent complications associated with regurgitation, it is important to protect anesthetized ruminants’ airway by placement of auffed endotracheal tube and positioning the head to allow regurgitant to flow out of oral cavity during lateral or dorsal recumbency.
- Injectable anesthetics may be administered via intravenous (IV) or intramuscular (IM) injection.
- An IV catheter, placed in jugular or auricular veins, is recommended for anesthesia maintained with continuous IV infusion.
- During recovery, ruminants should be placed in sternal recumbency and the endotracheal tube removed with cuff inflated.

### Incidence/Prevalence

**N/A**

### Geographic Distribution

Worldwide

### Systems Affected

N/A

### Pathophysiology

N/A

### Signalment

All ruminant species

### Genetics

N/A

### Causes and Risk Factors

N/A

### Diagnosis

**CBC/Biochemistry/Urinalysis**

May be indicated as preoperative workup.

### Treatment

N/A

### Medications

**Drugs of Choice**
- \( \alpha_2 \\) Agonists (Xylazine, Detomidine, Medetomidine, Romidatina)
- Classified as sedatives/analgesics.
- Produce profound sedation, analgesia and central muscle relaxation by binding to \( \alpha_2 \\) receptors in the CNS and spinal cord.
- Often use with an injectable anesthetic to produce general anesthesia.
- Ruminants are more sensitive to xylazine’s effect and only one tenth of the dose used in horses should be used.
- Doses required for detomidine, medetomidine, and romididine to produce sedation in ruminants are similar to the doses required for horses.
- At higher recommended doses, \( \alpha_2 \\) agonists induce analgesia, recumbency, and immobilization suitable for minor procedures.

### Contraindications

N/A

### Precautions

**Contraindications**

- Ruminants and camelids are more sensitive to xylazine’s effect.
- Use with caution in small ruminants.
- Xylazine should not be administered prior to sedation with \( \alpha_2 \\) antagonists.
- Xylazine is contraindicated in animals with urethral obstruction.
- Severe hypoxemia and pulmonary edema may precipitate if mix with water soluble solution.
- Midazolam is water soluble with two to three times more potency than diazepam.
- Diazepam has 40% propylene glycol as solvent in the injectable solution.
- Recommended dose ranges of xylazine are 0.1–0.2 mg/kg IV for cattle, sheep, and goats, 0.15–0.25 mg/kg IV for llamas and alpacas.
- Recommended dose ranges of medetomidine are 0.02 mg/kg IV for cattle and 0.025–0.05 mg/kg IV for llamas and alpacas.
- A \( \alpha_2 \\) antagonist (atipamezole, tolazoline, or yohimbine) can be given to reverse an \( \alpha_2 \\) agonist’s pharmacological effect.
- Recommended dose ranges of atipamezole are 0.02–0.06 mg/kg IV for cattle, 0.05–0.2 mg/kg IV for sheep and goats, and 0.125–0.25 mg/kg IV for llamas and alpacas.
- Recommended dose ranges of tolazoline are 0.2–2 mg/kg IV for cattle and 1–5.5 mg/kg IV for sheep, goats, llamas, and alpacas.
- Recommended dose ranges of yohimbine are 0.12–0.2 mg/kg IV for cattle and 0.125–0.22 mg/kg IV for sheep, goats, llamas, and alpacas.

### Benzodiazepines (Diazepam, Midazolam, Zolazepam)

- Primary use for their anxiolytic, anticonvulsant, and central muscle relaxing effects.
- Have little or no analgesic effect.
- Produce minimal cardiovascular depression, used in animals with high anesthetic risk.
- Use with an injectable anesthetic to produce general anesthesia and improve muscle relaxation.
- Diazepam has 40% propylene glycol as solvent in the injectable solution.

### Possible Interactions

- Diazepam or midazolam is used in goats with urethral obstruction, when the effect of increasing urine output is contraindicated.
- Immobilization with good analgesia is produced when diazepam is combined with xylazine in cattle.
- Recommended dose ranges of diazepam are 0.1 mg/kg IV for cattle, 0.23–0.3 mg/kg IV for sheep and goats, and 0.1–0.2 mg/kg IV for llamas and alpacas.
- Recommended dose of midazolam is 0.4 mg/kg IV.

### Precautions

**Propylene glycol may cause hypotension if diazepam is administered IV rapidly.**

### Possible Interactions

Additive or synergistic effect with other anesthetics.

**Dissociative Anesthetics (Ketamine, Thiopental)**

- Dissociative anesthesia is characterized by unconsciousness while maintaining eye reflexes, pupil reflexes, and pharyngeal-laryngeal reflexes (swallowing and coughing reflexes).
- Ketamine induces rapid onset and short duration of anesthesia and analgesia. When administered alone, muscle relaxation is inadequate for more painful surgery. Often combine with xylazine or diazepam for their central muscle relaxing effect.
- Subanesthetic doses of ketamine produce profound analgesia by blocking N-methyl-D-aspartate receptors.
- Recommended dose ranges of ketamine are 2–4.5 mg/kg IV for cattle, 1–5.5 mg/kg IV for sheep and goats, and 3–5 mg/kg IV for llamas and alpacas.

### Overview

**General anesthesia produces unconsciousness, analgesia, and muscle relaxation for surgical or diagnostic procedures.**

**To prevent complications associated with regurgitation, it is important to protect anesthetized ruminants’ airways by placement of auffed endotracheal tube and positioning the head to allow regurgitant to flow out of oral cavity during lateral or dorsal recumbency.**

**Injectable anesthetics may be administered via intravenous (IV) or intramuscular (IM) injection.**

**An IV catheter, placed in jugular or auricular veins, is recommended for anesthesia maintained with continuous IV infusion.**

**During recovery, ruminants should be placed in sternal recumbency and the endotracheal tube removed with cuff inflated when the patient regains swallowing and coughing reflexes.**

**Incidence/Prevalence**

**N/A**

**Geographic Distribution**

Worldwide

**Systems Affected**

N/A

**Pathophysiology**

N/A

**Signalment**

All ruminant species

**Genetics**

N/A

**Causes and Risk Factors**

N/A

**Diagnosis**

**CBC/Biochemistry/Urinalysis**

May be indicated as preoperative workup.

**Treatment**

N/A

**Medications**

**Drugs of Choice**
- \( \alpha_2 \\) Agonists (Xylazine, Detomidine, Medetomidine, Romidatina)
- Classified as sedatives/analgesics.
- Produce profound sedation, analgesia and central muscle relaxation by binding to \( \alpha_2 \\) receptors in the CNS and spinal cord.
- Often use with an injectable anesthetic to produce general anesthesia.
- Ruminants are more sensitive to xylazine’s effect and only one tenth of the dose used in horses should be used.
- Doses required for detomidine, medetomidine, and romididine to produce sedation in ruminants are similar to the doses required for horses.
- At higher recommended doses, \( \alpha_2 \\) agonists induce analgesia, recumbency, and immobilization suitable for minor procedures.

**Contraindications**

Animals with severely compromised cardiovascular functions.

**Precautions**
- Side effects: bradycardia, hypotension, decreased respiratory rate, cardiac arrhythmias, decreased gutturostral (GL) motility, hypotension, hypertension, increased urine output, and oxytocin-like effect.
- Premature parturition has occurred in pregnant ruminants with xylazine during the last trimester.
- Severe hypoxemia and pulmonary edema can occur in sheep.
- In animals with urethral obstruction, rupture of bladder can result from increased urine output.
- Ruminants and camels are more sensitive to xylazine’s toxicity effect. Low recommended dose and slow IV injection should be used.

**Possible Interactions**

Additive or synergistic effect with other anesthetics.
## Ruminant, Second Edition

### Anesthesia: Injectable

#### Table 1

Drugs Used for Injectable Anesthesia in Cattle, Small Ruminants, and Camelids.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Cattle</th>
<th>Sheep &amp; Goats</th>
<th>Alpacas &amp; Llamas</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diazepam</td>
<td>0.1, IV</td>
<td>—</td>
<td>—</td>
<td>Immobilization with good analgesia for 30 min Total recumbency 60 min</td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.2, IV</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Diazepam</td>
<td>0.1, IV</td>
<td>0.1–0.2, IV</td>
<td>0.1–0.2, IV</td>
<td>Anesthesia 10–15 min Total recumbency 30 min</td>
</tr>
<tr>
<td>Ketamine</td>
<td>4.5, IV</td>
<td>4, IV</td>
<td>4, IV</td>
<td></td>
</tr>
<tr>
<td>Medetomidine</td>
<td>0.02, IV</td>
<td>0.02, IV</td>
<td>0.025, 0.035, or 0.05, IM</td>
<td>Anesthesia 70–120 min in calves Light anesthesia for 30–60 min in camels</td>
</tr>
<tr>
<td>Ketamine</td>
<td>2.2, IV</td>
<td>1–2, IV</td>
<td>1–1.5, IM</td>
<td></td>
</tr>
<tr>
<td>Midazolam</td>
<td>—</td>
<td>0.4, IM</td>
<td>—</td>
<td>Anesthesia 15 min</td>
</tr>
<tr>
<td>Ketamine</td>
<td>—</td>
<td>4, IV</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.1–0.2, IV</td>
<td>0.1, IV</td>
<td>0.15–0.25, IV</td>
<td>Anesthesia 30 min Preferred combination for adult large ruminants</td>
</tr>
<tr>
<td>Ketamine</td>
<td>2, IV</td>
<td>0.2, IM</td>
<td>0.1, IM</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.1–0.2, IV</td>
<td>2.2, IV</td>
<td>3–5, IV</td>
<td></td>
</tr>
<tr>
<td>Ketamine</td>
<td>2, IV</td>
<td>3–5, IM</td>
<td>3–5, IV</td>
<td></td>
</tr>
<tr>
<td>BKX</td>
<td>Butorphanol</td>
<td>0.0375, IM</td>
<td>1 mL/23 kg, IM; 1 mL/45 kg, IV</td>
<td></td>
</tr>
<tr>
<td>Ketamine Xylazine</td>
<td>3.75, IM</td>
<td>3 mL/78 kg, IM Llamas: 1 mL/23 kg, IM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified BKX</td>
<td>Butorphanol</td>
<td>—</td>
<td>0.02 mL/kg, IV</td>
<td>Mixture: add 8 mg of X, 8 mg of B into 400 mg (4 mL) of K For debudding in young animals</td>
</tr>
<tr>
<td>Ketamine</td>
<td>0.03, IV</td>
<td>0.03, IV</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>1.6, IV</td>
<td>1.6, IV</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.03, IV</td>
<td>0.03, IV</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Bovine Triple Drip</td>
<td>Xylazine (0.1 mg/mL)</td>
<td>1 mL/23 kg, IM</td>
<td>Alpacas: 1 mL/78 kg, IM</td>
<td>Anesthesia 20–30 min</td>
</tr>
<tr>
<td>Ketamine</td>
<td>0.67–1.1 mL/kg</td>
<td>3 mL/78 kg, IM Llamas: 1 mL/23 kg, IM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>into 5% Guaiifenesin</td>
<td>Maintenance: 2.2 mL/kg/hr</td>
<td>Maintenance: 2.2 mL/kg/hr</td>
<td>Maintenance: 2.2 mL/kg/hr</td>
<td>Stable plane of anesthesia Smooth recovery</td>
</tr>
<tr>
<td>Propofol</td>
<td>4–6, IV</td>
<td>Induction: 3–4, IV or 4–8, IV</td>
<td>Induction: 3–3.5, IV</td>
<td>Anesthesia 5–10 min, single dose Apnea may occur CRI: 24 mg/kg/hr for maintenance of light anesthesia</td>
</tr>
<tr>
<td>Telazol</td>
<td>4, IV</td>
<td>Induction: 18–40 mg/kg/hr</td>
<td>Induction: 24 mg/kg/hr</td>
<td></td>
</tr>
<tr>
<td>Telazol</td>
<td>2–4, IV</td>
<td>2, IV or 4.4, IM</td>
<td>2, IV or 4.4, IM</td>
<td>Anesthesia 45–60 min Stable plane of anesthesia Prolonged recovery</td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.1, IM</td>
<td>—</td>
<td>0.25, IV</td>
<td>Anesthesia 60 min Standing in 130 min</td>
</tr>
<tr>
<td>Xylazine</td>
<td>4, IM</td>
<td>—</td>
<td>1, IV</td>
<td></td>
</tr>
<tr>
<td>TKX-Ru</td>
<td>1.25–1.5 mL/125 kg</td>
<td>1.25–1.5 mL/kg, IM for smaller patients 1 mL/110–115 kg, IM for larger patients</td>
<td>Mixture: Add 2.5 mL (250 mg) of K and 1 mL (100 mg) of X into 500 mg of Telazol Allow 20 min to reach peak effect Effective for capture wild ruminants Deep sedation, recumbency and chemical restraint in camels; awake and assume sternal recumbency in 40–60 min</td>
<td></td>
</tr>
</tbody>
</table>
Telazol® is a combination of a tiletamine and zolazepam, in a 1:1 ratio by weight base. Telazol® comes as 500-mg powder, and is reconstituted with 5 mL sterile water into 100 mg/mL solution. Telazol® can be reconstituted with a smaller volume of sterile water with higher concentration, like adding 2.5 mL sterile water into 500-mg powder, resulting in a final concentration of 200 mg/mL.

The pharmacologic effect of Telazol® is predominated by tiletamine. Similar to diazepam and midazolam, zolazepam produces minimal cardiovascular depression. Thus, Telazol® anesthesia is characterized by that of ketamine anesthesia, but better muscle relaxation, more profound analgesia, and longer duration of anesthesia.

Recovery from Telazol® anesthesia tends to be smooth but prolonged in ruminant as a result of slower metabolism and elimination of zolazepam.

Recommended dose ranges of Telazol® are 4–6 mg/kg IV for cattle, 2–4 mg/kg IV for sheep and goats, and 1–2 mg/kg IV for llamas and alpacas.

CONTRAINDICATIONS
N/A

PRECAUTIONS
• Ketamine increases salivation and mucous secretion in the respiratory tract, which can be reduced by administration of an anticholinergic, e.g., atropine.
• Prolonged recovery may follow Telazol® anesthesia.

POSSIBLE INTERACTIONS
Additive or synergistic effect with other anesthetics.

Guaifenesin (Glycerol Guaiacolate; GG)
• Administered alone, GG produces muscle relaxation, ataxia, and recumbency.
• Minimal changes on respiratory muscle activity and respiratory rate at recommended doses of GG. Respiratory muscle paralysis occurs at doses 3–4 times higher than that required to induce recumbency.
• GG can be reconstituted with 5% dextrose to make up 5% or 10% injectable solution.
• Xylazine, ketamine, and GG combination (“bovine triple drip”) for induction and maintenance of anesthesia (see Table 1).

CONTRAINDICATIONS
GG does not produce anesthesia or analgesia. It should always be used with an anesthetic.

POSSIBLE COMPLICATIONS
Severe CNS and cardiopulmonary depression which may result in death if overdose.

FOLLOW-UP
POSSIBLE COMPLICATIONS
Severe CNS and cardiopulmonary depression which may result in death if overdose.

PATIENT CARE
Closely monitor vital signs: eye reflexes, heart rate, rhythm, respiratory rate and depth, and arterial blood pressures.

MISCELLANEOUS

PREGNANCY
• Premature parturition has occurred in pregnant ruminants with xylazine during the last trimester.
• Reduced anesthetic requirement in pregnant animals.

ABBREVIATIONS
• CNS = central nervous system
• GG = guaifenesin (glycerol guaiacolate)
• GI = gastrointestinal

SEE ALSO
• Anesthesia: Inhalation
• Anesthesia: Local and Regional
• Common Pharmacologic Therapies: Adult Dairy Cattle (see www.fiveminutevet.com/ruminant)
• Pain Management (see www.fiveminutevet.com/ruminant)

Suggested Reading

Internet Resources
• FARAD: Food Animal Residue Avoidance Database. 2015. www.farad.org/amduca/amduca LAW.asp
• Author HaChu Lin
• Consulting Editor Katrina A. Laiz

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**Anesthesia: Local And Regional**

**OVERVIEW**

- Local or regional anesthesia with appropriate patient restraint provides the most cost-effective method of humane analgesia and analgesia in ruminants.
- Fractious animals may also require sedation.
- Local or regional anesthesia causes a reversible loss of sensation to an area without loss of consciousness. Some techniques (i.e., L5 epidural) can affect motor function if motor nerves are targeted.
- These techniques should not be used as the sole source of analgesia but can be used in conjunction with NSAIDs and/or systemic opioids for optimal analgesia.

**SYSTEMS AFFECTED**

- Nerves
- Musculoskeletal

**PATHOPHYSIOLOGY**

All LA will block sodium channels and can affect muscle, cardiac, and smooth muscle.

**CAUSES AND RISK FACTORS**

- Variety of procedures from castration or dehorning to abdominal exploratory procedures.
- Siddiqui block, bovine, ovine, caprine:
  - Ovine and caprine: 2.5 cm, 22G needle with 2–3 mL 2% lidocaine injected SQ halfway between the lateral canthus and the medial edge of the horn base.
  - Caudal (sacrococcygeal or intercoccygeal) epidural block, bovine:
    - The space is located between S5-Co1 or Co1-Co2 and is easily palpable with the thumb and index finger. A 3.8 cm or 7.5 cm, 20 or 22G spinal needle is inserted on midline between L6 and S3. Confirmation of correct placement is usually done by the hanging drop technique where saline will be pulled by negative pressure into the epidural space. A dose of 0.01–0.02 mL/kg of 2% lidocaine will provide anesthesia up to the pelvic region.
- Anesthesia of Pelvic Area
  - Cranial (lumbosacral) epidural block, bovine:
    - Ovine and caprine: 3.8 cm or 7.5 cm, 20 or 22G spinal needle is inserted on midline between L6 and S3. Confirmation of correct placement is usually done with the hanging drop technique where saline will be pulled by negative pressure into the epidural space. A dose of 0.01–0.02 mL/kg of 2% lidocaine will provide anesthesia up to the pelvic region.
- Anesthesia of the Flank and Paralumbar Fossa
  - Proximal paravertebral block, bovine: The area should be prepped from the last rib to the TP of L4 about 4–5 cm from midline. A 3.8 cm, 16G needle is used as a guide for a 9.8 cm, 20G spinal needle. The cannula needle is placed thru the skin at anterior edge of TP of L1, 4–5 cm from dorsal midline. The spinal needle is passed thru the transverse ligament into the area of interest. Then withdraw the needle to 2.5 cm over the fascia and deposit an additional 2–3 mL for the dorsal branch and 2–3 mL for the ventral branch with 2% lidocaine. Do not exceed 5–6 mg/kg total.
  - Distal paravertebral block, bovine: The area of the block is clipped and prepped from T13 to L3 on the lateral aspect. A 3.5–5.5 cm, 18G needle is inserted ventral to the TP and 10 mL of LA is infused in a fan pattern. The needle is then redirected or reinjected dorsally and LA is infused caudally in a fan pattern as well. Repeat at the other sites.
- Anesthesia of the Linea Alba and Paramedian Region
  - Cranial (lumbosacral) epidural block, bovine: This is done alone or with a paramedian block, where saline will be pulled by negative pressure into the epidural space. A dose of 0.01–0.02 mL/kg of 2% lidocaine will provide anesthesia up to the pelvic region.

**TREATMENT**

**Anesthesia for Dehorning and Castration**

- It is well documented that LA should be used in conjunction with NSAIDs for optimal analgesia.
- It is important to consider the type of LA to be used and to monitor for potential adverse effects.
- LA should be used in conjunction with NSAIDs and/or systemic opioids for optimal analgesia.
- LA should be used in conjunction with NSAIDs and/or systemic opioids for optimal analgesia.

- Anesthesia for Dehorning and Castration: Bovine, Ovine, Caprine
  - Indicate LA into the skin at the proposed incision site to desensitize the skin. Inject LA into the center of the teat until it is firm to the touch. The LA will migrate into the parietal cord.
  - Anesthesia of the Eyelid and Eye
    - Auriculopalpebral block, bovine, ovine, caprine: 2.5 cm, 22G needle with 5 mL (2 mL in ovine and caprine) 2% lidocaine injected SQ on the dorsal zygomatic arch about 5–6 cm behind the supraorbital process.
    - Retrolabial block, bovine: 9 cm, 18 or 20G curved needle with 5–10 mL 2% lidocaine at each of 4 sites. The needle is passed thru the eyelids at the 12, 3, 6, and 9 o’clock positions around the eye. Ovine and caprine: 3.8 cm, 20 or 22G needle curved is inserted as above but only at sites (6 & 12 or 3 & 9 o’clock) with 2–3 mL 2% lidocaine per site.
    - Periocular block, bovine: 10–12 cm, 20G needle with 15–20 mL 2% lidocaine. The needle is directed at a 45° angle in small ruminants.
  - Anesthesia of the Nasal Passages
    - Nasal infratrochanteric block, bovine: 3.8 cm, 18G needle with 5–10 mL 2% lidocaine is injected SQ at the infraorbital canal. The foramen is located 5 cm above the second premolar.
    - Anesthesia of the Nasal Passages
      - Nasal infraorbital block, bovine, ovine, caprine: 3.8 cm, 18G needle with 5–10 mL 2% lidocaine is injected SQ at the infraorbital canal. The foramen is located 5 cm above the second premolar.
  - Anesthesia of the Flank and Paralumbar Fossa
    - Proximal paravertebral block, bovine: The area should be prepped from the last rib to the TP of L4 about 4–5 cm from midline. A 3.8 cm, 16G needle is used as a guide for a 9.8 cm, 20G spinal needle. The cannula needle is placed thru the skin at anterior edge of TP of L1, 4–5 cm from dorsal midline. The spinal needle is passed thru the transverse ligament into the area of interest. Then withdraw the needle to 2.5 cm over the fascia and deposit an additional 6–8 mL for the dorsal branch. Continue this at the other sites. Ovine and caprine: Same technique as above with a 3.8 cm, 20G needle at S4-Co1 or Co1-Co2 with an injection volume of 0.01–0.02 mL/kg. The needle is redirected at a 45° angle in small ruminants.
- Anesthesia of the Teats and Udder
  - Suggested Reading: for these techniques including a ring block, inverted “V” block, and teat sinus infusion blocks. A proximal or distal paravertebral block extending from T13 to L4 can be used to block a majority of the teats.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

The type of block used will largely depend on clinician preference, position and temperament of the animal, and length of procedure.

**DRUGS OF CHOICE**

**Lidocaine**

- Only approved LA for use in cattle and sheep in the United States and Canada.
- The maximal effect occurs within 2–5 minutes of injection and lasts 90 minutes.
The addition of epinephrine (0.01 mg/mL) was found to increase the duration of activity to 304 minutes. However, epinephrine cannot be used in limb blocks or wound edges due to the potential risk of ischemia and tissue necrosis. The maximum dose is 6 mg/kg for ruminants.

**Bupivacaine and Mepivacaine**

- Off-label use
- The maximal effect occurs within 20–30 minutes and lasts 5–8 hours for bupivacaine. Mepivacaine behaves similarly to lidocaine.
- Bupivacaine exhibits the most cardiotoxic effects of all the LA and should be only used for SQ or infiltrative techniques. The maximum dose is 2 (bupivacaine) and 5–6 (mepivacaine) mg/kg. No withdrawal times have been established.

**CONTRAINDICATIONS**

- Regulatory restrictions: See “Suggested Reading” for links to the FDACVM and AMDUCA or recommendations for the use of LA in ruminants.
- Meat and milk withholding: See “Suggested Reading” for the link to FARAD and withdrawal times recommended.

**FOLLOW-UP**

N/A

**MISCELLANEOUS**

**ABBREVIATIONS**

- AMDUCA = Animal Medicinal Drug Use Classification Act
- FARAD = Food Animal Residue Avoidance Databank
- FDACVM = Food and Drug Administration Center for Veterinary Medicine
- LA = local anesthetics
- LS = lumbar sacral
- NSAIDs = nonsteroidal anti-inflammatory drugs
- SQ = subcutaneous
- TP = transverse process
- **SEE ALSO**
  - Alternative Medicine (see www.fiveminutevet.com/ruminant)
  - Anesthesia: Inhalation
  - Anesthesia: Injectable
  - Castration/Vasectomy: Bovine
  - Castration/Vasectomy: Cattle
  - Castration/Vasectomy: Small Ruminants
  - Dehorning
  - Enucleation/Exenteration (see www.fiveminutevet.com/ruminant)
  - Pain Management (see www.fiveminutevet.com/ruminant)

**Suggested Reading**


**Internet Resources**


**Author** Jennifer L. Bornkamp

**Consulting Editor** Kaitlyn A. Lutz
Anestrus

A

OVERVIEW
• Anestrus is the absence of estrus behaviors in female animals.
• Anestrus is physiological before puberty, between estrus periods, for a variable time after parturition or during lactation, during pregnancy, and seasonally in sheep and goats.
• Pathologic anestrus is the absence of estrus during a time when it would normally be expected to occur.
• Pathologic anestrus results from a disruption of the reproductive axis and typically involves the absence of both the behavioral signs of estrus and the underlying normal ovarian events associated with cyclic activity, although follicular waves may still occur.
• The most common clinical manifestation of anestrus is a delayed return to ovarian cycles after parturition. Anestrus is also used to describe animals undergoing normal ovarian cycles where the signs of estrus are missing, due either to deficiencies in management (undescribed estrus), subtle or absent signs of estrus (silent heat/subestrus), or both. The intensity and duration of estrus behavior may also be reduced or absent altogether at the first postpartum, seasonal or postpubertal ovulation in ruminants.
• Animals experiencing pathologic anestrus are usually anoestrous though some cases are associated with prolonged luteal function (CL retention).
• Follicular growth may be arrested at any stage of development as reflected in the size of structures found on the ovaries. Growth and persistence of follicular structures beyond the normal ovariolar size and duration is defined as OVD.

INCIDENCE/PREVALENCE
• The incidence of anestrus varies widely with the specific condition on the farm and the species affected.
• In dairy cows, for example, the incidence of delayed return to estrus after parturition in four recent reports ranged from 29 to 54% in primiparous cows and from 15 to 32% in multiparous cows.

GEOGRAPHIC DISTRIBUTION
Worldwide

SYSTEMS AFFECTED
Reproductive
PATHOPHYSIOLOGY
• Pathologic anestrus may be the result of a primary disruption or disease at the level of the hypothalamus, pituitary, or ovary.
• Commonly, anestrus is secondary to disease or derangement in some other body system. Examples include nutritional deficiencies, especially energy; chronic severe illness, pain or stress resulting in a loss of body condition; heat stress; and uterine disease with or without retention of a CL.
• The endocrine basis for profound anestrus associated with very small follicles is unclear. Anestrus associated with follicular growth to the point of ovulation and beyond appears to be related to inadequate LH pulses for follicular development and the absence of an LH surge sufficient to cause ovulation.
• Anestrus occurring in association with prolonged luteal function is likely the result of inappropriate uterine PGF2α production, secretion, or transport to the ovary.
• Management deficiencies related to estrus detection can lead to a mistaken diagnosis of anestrus in otherwise normally cycling animals.
• In high-producing dairy cattle, increased liver metabolic rates related to high feed intake result in lower circulating levels of gonadal steroids with a subsequent depression of the length and intensity of estrus.
• In heat-stressed cattle, follicular steroidogenic capacity is reduced leading to lower blood estradiol concentration and diminished or absent signs of estrus.
• On rare occasion, anestrus in cattle may be iatrogenic due to inadvertent feeding of a progestational agent (e.g., MGA).

HISTORICAL FINDINGS
• Individual animals: Absence of cyclicity (estrus) beyond 60 days postpartum. Absence of estrus after a negative pregnancy diagnosis.
• Head or flock: Reduced mating activity, decreased pregnancy rates, increased interval from calving to first insemination, poor heat detection.

SIGNALMENT
• Sexually mature (postpubertal) female animals.
• Specific conditions vary with species and breed depending on nutrition, milk production levels, reproductive management systems, suckling intensity, seasonal (anestrus) influences, and the occurrence of systemic or uterine diseases.
• Suckled beef cattle will have a postpartum anestrus period 2 to 3 times as long as beef or dairy cattle that are milked.

PHYSICAL EXAMINATION FINDINGS
• Absence of sexually receptive behavior.
• Poor body condition score or other condition preventing expression of estrus.

GENETICS
• Ovarian agenesis, ovarian hypoplasia, and premature ovarian failure are rare examples of profound anestrus conditions and all probably have a genetic basis.
• The role of inheritance in the more common types of anestrus is uncertain.

CAUSES AND RISK FACTORS
• Poor nutritional management, especially in the transition period.
• High milk production and increased feed intake.
• Heat stress.
• Systemic disease.
• Lameness.
• Loss of body condition.
• Postpartum uterine infections (see chapter, Endometritis) can delay the resumption of normal cycles and increase the incidence of OVD.
• Long dry periods.
• Twin calving/Fremartinism.
• Primary uterine or fetal disease (e.g., pyometra, hydrople [goats], mummified fetus, prolonged gestation).
• Early postpartum ovulation (<25 days) is associated with a persistent or retained CL.
• Rarely, ovarian tumors, segmental aplasia, ovarian hypoplasia, mycotoxins, and micronutrient deficiencies.

DIFFERENTIAL DIAGNOSES
• Physiological anestrus (pregnancy, sexual immaturity, lactation, or seasonal).
• Ruling out pregnancy should be the first consideration, otherwise diagnostic and therapeutic procedures could potentially result in iatrogenic abortion.
• Fremartinism.
• Inadequate estrus detection/oviposition management deficiencies.

CBC/BIOCHEMISTRY/URINALYSIS
N/A

OTHER LABORATORY TESTS
Consistently low progesterone concentrations in serum or milk may confirm anovular (lacking ovulation) anestrus.

IMAGING
• Transrectal ultrasonography reveals persistently small inactive ovaries or failure to ovulate when larger follicles or cystic structures are present.
• Repeated examination may be necessary to confirm the diagnosis. A CL will be absent in most cases but, if present, the uterus should be carefully examined for evidence of pyometra or other uterine disease.

OTHER DIAGNOSTIC PROCEDURES
• Records analysis/histology.
• Observation for sexual activity as appropriate for each species.

PATHOLOGIC FINDINGS
N/A
**TREATMENT**

**THERAPEUTIC APPROACH**
- Correct nutritional deficiencies or other primary problems (e.g., lameness).
- Hormonal induction of estrus and/or ovulation.
- Heat abatement.

**SURGICAL CONSIDERATION AND TECHNIQUE**
Ovariectomy in case of GTCT.

**MEDICATIONS**

**DRUGS OF CHOICE**
- GnRH or hCG
- PG600 (combination of FSH and hCG) in sheep and goats
- PGF2α for retained/persistent CL, pyometra and hydrometra
- Ovulation synchronization (Ovsynch®) protocol with the addition of a CIDR
- Ovulation presynchronization protocols that include an injection of GnRH before the breeding Ovsynch®.

**CONTRAINDICATIONS**
PGF2α should not be given to pregnant animals.

**PRECAUTIONS**
N/A

**POSSIBLE INTERACTIONS**
N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
- Estrous cycles will resume once nutritional, reproductive, and management issues are addressed.
- Delay in initiating treatment increases the risk of culling for reproductive reasons.

**POSSIBLE COMPLICATIONS**
- Pyometra
- Delayed conception

**CLIENT EDUCATION**
Use appropriate methods for estrus detection and monitoring of breeding activity.

**PATIENT CARE**
- Monitor body condition score and behavioral activity.
- Heat abatement.
- Decreased dry period length for older cows.

**PREVENTION**
- Sound nutritional management, especially in the transition period, to avoid excessive loss of body condition.
- Minimize the incidence of dystocia, retained fetal membranes, and metritis/endometritis.
- Heat abatement.

**AGE-RELATED FACTORS**
In cattle, prolonged postpartum anestrus is more common in primiparous than in multiparous cows.

**ZOONOTIC POTENTIAL**
N/A

**PREGNANCY**
- Pregnant animals experience a normal, physiological anestrus.
- PGF2α will inevitably (goats and camels) or frequently (sheep and cattle) cause abortion.

**BIOSECURITY**
N/A

**PRODUCTION MANAGEMENT**
- Persistently anestrous females in well-monitored operations with strong management and husbandry protocols should be considered for culling.

**ABBREVIATIONS**
- CIDR = controlled intravaginal drug release device for delivery of progesterone
- CL = corpus luteum
- FSH = follicle stimulating hormone
- GnRH = gonadotropin-releasing hormone
- GTCT = granulosa-theca cell tumor
- hCG = human chorionic gonadotropin
- LH = luteinizing hormone
- MGA = melengestrol acetate
- OCID = ovarian cystic degeneration
- PGF2α = prostaglandin F2α

**SEE ALSO**
- Artificial Insemination: Bovine
- Artificial Insemination: Small Ruminant
- Body Condition Scoring (see www.fiveminutevet.com/ruminant)
- Endometritis
- Estrus Synchronization: Bovine
- Estrus Synchronization: Small Ruminants
- Freemartinism
- Heat Stress
- Ovarian Cystic Degeneration
- Ovarian Hypoplasia, Bursal Disease, Salpingitis
- Pyometra
- Uterine Anomalies

**Suggested Reading**

**Authors**
Harry Momont and Celina Checura

**Consulting Editor**
Ahmed Tibary

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Angular Limb Deformity

Angular limb deformity (ALD; “bent-leg”) is a deviation from the normal axis of a limb (in the frontal plane) and is defined by the joint involved and the direction that the distal aspect of the limb is deviated.

- Valgus deformity: The limb distal to the lesion deviates laterally.
- Varus deformity: The limb distal to the lesion deviates medially.
- ALDs are further described by the location of the pivot point (axis of deviation) and by the location of the site of defective growth.

Some ALDs are caused by asymmetrical lesions involving an active growth plate (e.g., distal radius), but growth plate damage is not always the underlying cause.

- Related conditions include fleural deformities, tendon injuries, joint luxations/joint instability caused by laxity of supporting structures, and rotational/sural deformities.
- Hereditary chondrodysplasia (HC), or spider lamb syndrome, is a hereditary condition in young lambs characterized by a number of skeletal deformities, including angular limb deformities.

INCIDENCE/PREVALENCE

- Valgus and varus ALDs are common and well documented in horses, but are relatively rare in ruminants. Congenital limb abnormalities are reported to account for 6.9% of all congenital abnormalities in cattle.

GEOGRAPHIC DISTRIBUTION

Worldwide.

SYSTEMS AFFECTED

Musculoskeletal

PATHOPHYSIOLOGY

- ALDs are considered multifactorial in origin and have congenital/perinatal and developmental predisposing factors.
- Congenital ALDs may arise from environmental factors, genetic factors, or both. These include: toxins, placentitis, laxity of perilacrical soft tissues, and intrauterine or perinatal physical factors (e.g., swimming, trauma).
- Contributions to the formation of ALDs in immature and mature animals can stem from a low plane of nutrition, trauma, and excessive limb loading.
- In llamas, the distal ulnar epiphysis fuses with the distal radial epiphysis. This unique development of the distal portion of the ulna is associated with forearm-valgus deformities in crias. The ulnar epiphysis extends distally, crosses the radial physeal region.

HISTORICAL FINDINGS

A complete history including current age, birth details, age at which the deformity was noticed, course and progression of the deformity, and diets of affected animal and dam should be obtained.

SIGNALMENT

Species
- Bovine, ovine, caprine, South American camelids (especially llama crias), cervids—including fallow deer (Dama dama), red deer (Cervus elaphus), white-tailed deer (Odocoileus virginianus)—and a single case report of ALD in a giraffe calf (Giraffa camelopardalis).

Bread Predictions
- ALDs have been described in many different herd and dairy cattle breeds.
- HC primarily affects black-faced breeds of sheep (Suffolk, Hampshire, Southdown, Shropshire, and Oxford).
- Varus/varus deformities have been described in the distal radial physeal region of earing formed male red and white-red consubsid ide (id) deer in New Zealand.

Mean Age and Range
- ALDs primarily affect young growing animals up to 7 months of age, but can be seen in older animals (e.g., trauma-induced ALD).
- HC has two distinct clinical entities: lambs are either grossly abnormal at birth or develop the abnormal conformation at 4–6 weeks of age. Radiographic changes at birth are similar for both.

Predominant Sex
No apparent sex predisposition.

PHYSICAL EXAMINATION FINDINGS

- Conformation should be assessed first by having the animal stand in a symmetric manner on a firm, flat surface and observing it from multiple angles. Affected animals may appear to be knock-kneed or bow-legged. All limbs should be palpated and affected limbs should be manually manipulated. Clinical signs such as abnormal bending of the affected limb, increased laxity, muscle atrophy, swelling, heat, pain on manual pressure, abrasions on lateral or medial side of hoof wall, presence of orthopedic injury, and abnormal gait and locomotion are indicative of ALD.
- Compensatory deviation (opposite to the affected limb) is relatively common in the contralateral limb.
- If varus deformity is found unilaterally, the contralateral limb should be examined for a significant orthopedic injury as a cause of excessive weight-bearing in the deformed limb/joint.
- Since cattle are considered to have a “normal” degree of medial deviation at the level of the carpus and hock, as well as normal external rotation of the lower limb, ALDs tend to be missed in the early stages of development.
- Most bovine ALDs occur at the level of the mid-diaphysis of long bones.
- In sheep affected with HC, various degrees of ALDs of fore- and/or hindlimbs will be noted. Other physical examination findings include severe scoliosis of the thoracic spine, pectoral excavatum, arthritic growth rates, facial deformities such as angular deviation and/or shortening of maxilla, rounding of the dorsal silhouette, and Roman-shaped noses.

GENETICS

- The questions of heritability in ALDs have not been definitively answered; the details of some syndromes are known. ALDs in Jersey calves are genetically transmitted as a simple autosomal recessive trait.
- HC of Suffolk and Suffolk-cross sheep is inherited as a single, autosomal recessive gene that has been localized to the distal end of chromosome 6. A defect in the gene encoding fibrillogenesis factor receptor 3 (FGFR3) is suspected. DNA tests (blood or semen) are available to identify homozygous and heterozygous animals.

CAUSES AND RISK FACTORS

- ALDs are often related to asymmetrical growth of the physe, ligament rupture, or orthopedic injuries.
- Congenital Predisposing Factors
  - Incomplete boculoid bone ossification (cantal and/or tarsal).
  - Physologic immaturity at birth.
  - Uterine malpositioning.
  - In utero bending stress and bone remodeling early in gestation.
  - Twin (or triplet) pregnancy.
  - Reduced intrauterine space (bone movement during gestation).
  - Excessive exercise.
- Nutritional disorders (e.g., improper dietary calcium and phosphorus ratios; copper, zinc, manganese, iron, and molybdenum concentrations).
- External trauma (e.g., compression of or trauma to growth plate).
- Nutritional imbalance during gestation.
- genital causes.

Developmental Predisposing Factors

- Conformational defects (causing abnormal weight distribution across a joint).
- Nutritional factors (e.g., improper dietary calcium and phosphorus ratios; copper, zinc, manganese, iron, and molybdenum concentrations).
- External trauma (e.g., compression of or trauma to growth plate).
- Nutritional (e.g., assisted delivery).
- Genetic cause.
- Nutritional factors (e.g., improper dietary calcium and phosphorus ratios; copper, zinc, manganese, iron, and molybdenum concentrations).
- Nutritional imbalance during gestation.
- Genetic cause.

Camelids

- May see ALDs (usually carpal valgus) in growing camels with hypophosphatemic rickets syndrome.
- Ilih-syringe syndrome in llamas may be associated with ALDs as well as anemia, low serum iron concentrations, and metabolic disorders (hypothyroidism).
- Underlying cause not established.
**Angular Limb Deformity (Continued)**

**DIAGNOSIS**

**DIFFERENTIAL DIAGNOSES**
- Physiologic deformities: • Metabolic bone disease (e.g., rickets). • HC may be confused with arthrogryposis-hydranencephaly syndrome (AHS) in lambs, in which there is characteristic hyperlaxation of foal limbs, cranial overextension of hindlimbs, with a corkscrew deviation of the spine. In lambs with AHS, severe deformities result from primary abnormalities of the CNS (including hydranencephaly and others) and not of the skeleton.
- Camelids: True ALDs in llamas must be differentiated from valve deformities of the forelimbs in newborn crias that self-correct without surgical treatment.

**CBC/BIOCHEMISTRY/URINALYSIS**

- There are usually no associated laboratory abnormalities with ALDs. • HC results in slightly elevated serum alkaline phosphatase activity; insufficient for diagnostic purposes.

**OTHER LABORATORY TESTS**

- N/A

**IMAGING**

- Radiographs are critical in diagnosing ALDs—at least two views, 90 degrees apart, should be taken of the affected joints, including joints immediately proximal and distal to the affected joint. • The dorsoplantar/dorsoplantar (D/P) view is needed for examination of the anatomical location of the deformity and for measurements. The pivot point is defined as the intersection between lines drawn through the long axis at the center of the proximal and distal long bone using the dorsoplantar view. Location of the pivot point identifies the type of deformity. Measure the angle of deviation with a protractor. • HC: Most consistent lesions include multiple islands of ossification of the anconal process and malformed, displaced sternecra. The anconal lesions of HC are progressive, whereas similar lesions in other skeletal conditions of lambs regress.

**PATHOLOGIC FINDINGS**

- Histologic: • Focal or segmental thickening of the physeal (expansion of the hypertrophic zone) with extension into the proximal metaphysis; closely resembles physical manifestations of osteochondroses. • Histology associated with HC (vertebrate and long bones): Increase in width of the zone of proliferation and hypertrophy and unevenness of growth cartilage; failure to form or maintain orderly columns of chondrocytes.

**TREATMENT**

**THERAPEUTIC APPROACH**

- Treatment of neonatal animals with incomplete ossification involves the application of tube casts or splints to the affected limb(s) until ossification is complete (based on repeated radiographs). • Many cases of ALD will resolve without surgery if the underlying cause(s) can be identified and addressed and if the animal does not damage the affected phys or joints with vigorous exercise. • Specific treatment methods are selected on the basis of age, degree of angulation, remaining growth potential of the involved physeal, and experience of the veterinarian. • Minor limb deformities may be conservatively treated by manual alignment and external support of the limb (e.g., rigid splinting, bandaging, or casting/tube casts) and/or hoof (claw) trimming. • Hoof manipulations create growth plate response to stress applied opposite the deformity, and self-correction occurs. The hoof tends to turn in the direction of the longer claw or toward the side of the wider wall, resulting in straightening and de-rotation of the limb. • Medial (varus) deformities can be treated by trimming the medial claw shorter than the lateral claw and by placing an acrylic (methyl methacrylate) wing on the weight-bearing surface of the lateral claw (to increase lateral contact with the ground). • Treatment should be directed at the orthopedic injury when vara deformity is present secondary to a contralateral limb injury.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

- Surgery is recommended for older animals (near the end of active physal growth), for those that do not respond to conservative treatments, and for animals with bone malformations that require realignment (via osteotomy). • The choice of surgical technique should take into consideration the economic value and age of the animal, severity of the deformity, and the joint involved.

**GUIDELINES**

- When to Operate: To delay surgery beyond the growth phase and to correct the deformity is optimal. • Many cases of ALD are corrected with intraarticular injections or periosteal procedures. • This allows further growth before committing to invasive surgical treatment. • When to Operate: To delay surgery beyond the growth phase and to correct the deformity is optimal. • Many cases of ALD are corrected with intraarticular injections or periosteal procedures. • This allows further growth before committing to invasive surgical treatment.

**TREATMENT STRATEGIES INCLUDE THE FOLLOWING**

**Growth Acceleration (Periosteal Stripping/Elevation)**

- In young calves and lambs with early cases of ALD, surgical growth stimulation via periosteal stripping on the concave aspect (shorter side) of the deformity has been used successfully. Based on the remaining growth potential, prolonged the SD administration and allows the other side to continue growing, resulting in limb straightening. • The surgical implants must be removed when the limb achieves normal conformation to prevent overcorrection. This can be used in combination with peristomal stripping to increase the likelihood of full correction in animals with severe deviations.

**Corrective Wedge Osteotomy**

- This procedure is indicated in mature animals with ALD and in neonates with congenital fracture malunion. If the growth plates are closed or if the growth plate is not involved in an ALD, a corrective osteotomy is recommended. This requires more experience and equipment and is reserved for valuable animals when response to other therapies has failed. • The site and orientation of the wedge is determined by clinical and radiographic examination. • The limb needs to be stabilized by internal fixation with a plate and screws for an extended postoperative period.

**Camelids**

- An ulcerous osteotomy must be done in conjunction with the peristomal transsection because the ulcer spans the radial physes.

**MEDICATIONS**

**DRUGS OF CHOICE**

- Nonsteroidal anti-inflammatory agents (NSAIDs) are recommended to reduce inflammation in some cases of ALD.

**CONTRAINDICATIONS**

- Prolonged NSAID administration has been associated with gastrointestinal (abomasal or CD) ulcers.

**PRECAUTIONS**

- Many of these affected animals are young; precautions regarding drug choices must take age into consideration. • Appropriate milk.
The prognosis for ill-thrift syndrome in llamas rarely survive the neonatal period.

Possible complications include muscle, tendon, and ligament atrophy/laxity, hyperextension of limbs, fibrous scar tissue development, and joint stiffness. Postoperative infection.

Prognosis is guarded, yet reasonable for affected animals is not recommended.

The majority of ALDs occur during the active growth phase of the affected bone joint. The majority of ALDs occur during the active growth phase of the affected bone joint.

A

Angular Limb Deformity

**POSSIBLE INTERACTIONS**

N/A

**FOLLOW-UP**

Expected course and prognosis

- Prognosis is guarded, yet reasonable for ALDs associated with growth plate imbalances, such as ill-thrift in llamas. Treatment for this condition includes appropriate vitamin D supplementation.
- Other dietary imbalances should be corrected while treating cases of ALD.
- Frequent physical monitoring and repeated radiographs should be done to assess the efficacy of corrective measures and to monitor progress.
- In cases of transphyseal bridging surgery, owner cooperation is required to determine when the limb has regained its normal conformation, at which time the implants must be removed to prevent overcorrection.

**PREVENTION**

Avoid breeding affected animals.

**ASSOCIATED CONDITIONS**

Conditions associated with ALDs include osteochondrosis of the physis, epiphysis, and incomplete ossification of the subchondral bone.

- Hyperaemia disease (premature physical closure) has been reported in calves due to overdose of vitamins A, D3, and E.
- Congenital lethal chondrodysplasia in Australian Dexter cattle: “Dexter bulldog calves”
- Congenital chondrodysplastic dwarfism in Holstein calves. Complex vertebral malformation is a familial syndrome of Holstein calves. Syndrome known as “brentleg” or “bougie” associated with ingestion of *Trachymene glauca* (wild parsnip) by pregnant ewes in Australia and New Zealand.

**AGE-RELATED FACTORS**

The majority of ALDs occur during the active growth phase of the affected bone joint.

**ZOONOTIC POTENTIAL**

N/A

**PREGNANCY**

Many of the causes of ALDs are congenital diseases in which the uterine environment is somehow disturbed (thrombosis, vascular supply, teratogens, mechanical factors, or prenatal viral infections). Cases of ALDs in goats pregnant with triplets have been reported. Contributing factors likely include stress and in utero malpositioning.

**BIOSECURITY**

N/A

**PRODUCTION MANAGEMENT**

N/A

**ABBREVIATIONS**

- ALDS = angular limb deformity
- CNS = central nervous system
- DP = dorsopalmar/dorsoplantar
- FGFR3 = fibroblast growth factor receptor 3
- HC = hereditary chondrodysplasia
- NSAIDs = nonsteroidal anti-inflammatory drugs

**SEE ALSO**

- Autografts
- Charcot joint
- Congenital Defective Bone
- Hereditary Chondrodysplastic Ovine
- Lameness (by species)

**Suggested Reading**


**Authors**

Erik J. Olson and Nicholas A. Robinson

**Consulting Editor**

Kaitlyn A. Lutz

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Anthelmintic Resistance

**HISTORICAL FINDINGS**

Lack of efficacy of anthelmintic treatment evidenced by poor fecal egg count reductions and increased clinical signs of parasitism.

**RELAPSE**

All ruminants may be affected.

**PHYSICAL EXAMINATION FINDINGS**

The signs of parasitism may be variable, depending upon the pathogenicity of the resistant parasites.

**GENETICS**

All ruminants may be affected, but it is most common to find that 20% of a herd will harbor 80% of the parasite. This fact suggests that a genetic component exists within a population of animals that allows the majority of the herd to have some level of resistance to internal parasites. The issue then becomes identifying those individuals within the herd that are most susceptible to continued infection and providing them with effective treatment.

**CAUSES AND RISK FACTORS**

Anthelmintic resistance in a nematode population is a phenotypic manifestation of a heritable, genetic trait within that population. The genetic basis and modes of inheritance of resistance are quite complex and differ widely among the various classes of compounds, but positive selection occurs whenever worms resistant to a particular drug are exposed to an anthelmintic to which they have lost their susceptibility.

**DIAGNOSIS**

DIFFERENTIAL DIAGNOSES

Any cause of weight loss may be considered as a differential for chronic parasitism. In sheep with *Haemonchus contortus* infections anemia and hypoproteinemia are predominant signs.

**OTHER LABORATORY TESTS**

The standard by which parasite loads are measured is the assessment of fecal egg counts per gram of feces (EPG). Fecal EPG of cattle tend to be less reflective of the adult worm burden when compared to sheep. This fact leads to a great deal of uncertainty in the detection of anthelmintic resistance in cattle. Resistance can be defined as a measurable decrease in efficacy of a compound against parasitic species and its larval stages that were previously susceptible.

**OTHER DIAGNOSTIC PROCEDURES**

The use of fecal EPGs on a herd basis is important to obtain knowledge of the efficacy of any anthelmintic. It is important to obtain an adequate sample size, although the number of animals with an adequate infection for enrollment can be limited. Recommendations to minimize diagnostic uncertainty include the use of arithmetic means to calculate anthelmintic efficacy, the use of individual based group means with pre- and post-treatment individual fecal egg counts, and the preferred use of diagnostic methods with higher analytic sensitivity to minimize inaccuracies in populations with low baseline fecal egg count.

**PATHOLOGIC FINDINGS**

The pathology associated with internal parasites is variable and dependent on the group.

**TREATMENT**

**THERAPEUTIC APPROACH**

The key to parasite control is either to prevent egg shedding and/or prevent larval uptake. For the last 50 years we have tried to prevent egg shedding by routine anthelmintic treatments. Managing animals to prevent larval uptake can be accomplished by co-grazing different species, removal of faeces or clever use of available pasture lands. The assessment of the drug disposition in the host and increased knowledge of the mechanisms of drug interaction in the targeted parasites has increased our understanding of how these anthelmintics actually work. It is clear that we need additional scientific knowledge on how to improve the use of available molecules to avoid or delay development of resistance.

**MEDICATIONS**

- See Follow-Up
- See chapters, Parasite Control Programs

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**

This is a life-threatening aspect of small ruminant production and serious consequences will occur if solutions are not forthcoming.

**POSSIBLE COMPLICATIONS**

Very limited information is available on the potential additive or synergistic effects occurring after co-administration of two (or more) drugs with different modes of action.

**CLIENT EDUCATION**

A change in treatment philosophy is necessary to combat or delay the development of anthelmintic resistance in ruminant nematodes. Producers have used dewormers in a very cavalier manner over the past 40 years.

**OVERVIEW**

Gastrointestinal nematodes are common and may cause pathology that impacts health and welfare of infected animals. Intensification with these nematodes decreases production parameters. Control measures have relied predominantly on periodic administration of anthelmintic drugs to the entire herd or flock. Their continual use has led to the selection of populations of drug-resistant worms worldwide. Multi-drug resistance has now been reported in sheep and cattle. Anthelmintic resistance by *Haemonchus contortus* in sheep has been well documented and in cattle recent reports of resistance in *Cooperia* spp. and to a lesser extent in *Ostertagia ostertagi* are now documented.

**INCIDENCE/PREVALENCE**

Each farm may have different levels of resistant parasite populations. The level of resistance is dependent on how frequently the herd has been treated with anthelmintics and how effective those compounds have been in reducing luminal burdens.

**GEOGRAPHIC DISTRIBUTION**

*Worldwide*

**SYSTEMS AFFECTED**

Gastrointestinal, which may lead to pathology of other organ systems with significant infections.

**PATHOPHYSIOLOGY**

Individual nematodes that survive an anthelmintic treatment have a reproductive advantage in the absence of competition by susceptible worms in the intestine. This advantage persists until lifecycle features prevail or anthelmintic levels decrease and allow reestablishment of susceptible parasites. Resistant worms transmit their unique, heritable traits to the next generation and by doing so they increase the frequency of their genetic alleles in the general population.

Depending upon the parasite, the clinical significance of the infection may be greater than would be present if the treatment was more effective. Resistant worms have no particular advantage until the selection pressure of anthelmintic treatment is applied. Once this happens, a great way to accentuate this advantage is to repeatedly use the same anthelmintic. Individual worms are initially resistant to only one class of anthelmintics, so when “drug A” is used, they survive, but if “drug B” were then used, the worms would be removed like the rest of the susceptible population. Thus, the reproductive advantage of resistant worms would be favored if “drug A” were used exclusively.

**DIAGNOSIS**

DIFFERENTIAL DIAGNOSES

Any cause of weight loss may be considered as a differential for chronic parasitism. In sheep with *Haemonchus contortus* infections anemia and hypoproteinemia are predominant signs.

**MEDICATIONS**

- See Follow-Up
- See chapters, Parasite Control Programs

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**

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**POSSIBLE COMPLICATIONS**

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**CLIENT EDUCATION**

A change in treatment philosophy is necessary to combat or delay the development of anthelmintic resistance in ruminant nematodes. Producers have used dewormers in a very cavalier manner over the past 40 years.
years and been taught that when deworming, all animals in the herd must be treated. New knowledge and evidence point out that this technique has helped to create the resistance that is now present. Educating producers on how to address parasite problems must be done and this knowledge needs to encompass feed stores and pharmaceutical supply houses as well.

**PATIENT CARE**
The individual monitoring within a herd will be necessary to allow for identification of those that have the highest parasite loads.

**PREVENTION**
- Integrated management and pharmacologic intervention.
- Treatment targeted at those individuals that harbor the most parasites and are at risk for the development of adverse clinical signs.
- Different pharmacokinetic-based approaches to enhance parasite exposure.
- Mixed-class anthelmintic treatment.

**MISCELLANEOUS**

**PREGNANCY**
Chronic parasitism may significantly affect gestating dams, especially in small ruminants infected with *H. contortus*.

**BIOSECURITY**
Anytime a new animal is brought on to a property they should be evaluated for their internal parasite load. This is especially critical in small ruminant populations with *Haemonchus contortus*. Purchased additions should be screened and quarantined to evaluate their existing infestation and, if they are infected, their response to treatment.

**PRODUCTION MANAGEMENT**
Production is imperative to success in ruminants and internal parasites are a major contributor to production losses. Control of these parasites is critical for success in rearing young stock.

**ABBREVIATION**
- EPG = egg count per gram of feces

**SEE ALSO**
- Parasite Control Programs: Beef
- Parasite Control Programs: Canceled
- Parasite Control Programs: Dairy
- Parasite Control Programs: Small Ruminant

**Suggested Reading**
- Smith LL. Combination anthelmintics effectively control ML-resistant parasites; a real-world case history. Vet Parasitol 2014, 204: 12–17.

**Author**
Dennis D. French

**Consulting Editor**
Kaitlyn A. Lutz

**Client Education Handout available online**
BASICS

OVERVIEW
• Anthrax is a bacterial disease that many animals are susceptible to, including humans. It is caused by Bacillus anthracis which is present in the soil.
• It is seen most often in and is highly pathogenic for most wild and domestic herbivores.
• In most areas anthrax is a reportable disease and the regional veterinary authorities should be notified of an outbreak.
• In the USA, Bacillus anthracis is listed in the Federal Select Agent Program.

INCIDENCE/PREVALENCE
• Anthrax spores are endemic in parts of the United States, where occurrence of clinical disease is usually sporadic.
• Both sporadic cases and outbreaks are often associated with disruptions of the soil.
• Morbidity varies widely but case mortality is 90–95%.

PHYSICAL EXAMINATION FINDINGS
• Commonly animals will be found dead and clinical signs not observed.
• Clinical signs include fever up to 107°F (41.5°C), congested mucous membranes, excitement, depression, stupor, dyspnea, ataxia, muscle tremors, collapse, convulsions, and death. Younger animals will have less severe signs.
• If the animal lives long enough bloody diarrhea, hematuria, and localized swellings may be seen as well as abortion.

CAUSES AND RISK FACTORS
• Anthrax is caused by Bacillus anthracis which is a large (1 μm by 3–5 μm) Gram-positive rod that is rectangular with square ends and commonly forms chains.
• Bacillus anthracis exists in two forms: the spore and vegetative cell.
• Once the spore infects the animal it germinates into the vegetative form. The vegetative form in infected tissues of the dead animal only survives up to 1–2 weeks. However, when exposed to air vegetative bacteria will sporulate in several hours. Sporulation is oxygen dependent.
• It is important not to necropsy the carcass to limit the spore formation and therefore keeping contamination of the environment to a minimum.
• Scavengers and biting insects may mechanically disseminate anthrax after feeding on affected carcasses.
• Risk factors include:
  • Animals residing in endemic pastures or range.
  • Exposure to disturbed soil in endemic areas. Disturbances can be due to flooding, excavations, cattle disturbing soil around wet pastures, or shrinking surface water sources.
  • Grazing plants close to the ground, as seen in overstocking range or pasture or drought in endemic areas.

DIAGNOSIS

DIFFERENTIAL DIAGNOSES
Anthrax, because of the nonspecific history and clinical appearance, can be confused with many other causes of acute death in ruminants including clostridial infections (blackleg, malignant edema), lightning strike, acute tonsillo-lymphadenitis, and blastomyces.

ANIMALS AFFECTED
• Hemolympathic
• Multiorgan

PATHOPHYSIOLOGY
• Soil-borne spores are the infective form of the bacteria.
• In ruminants the main source of infection is consuming spore-contaminated pasture or feed. However, spores can enter the host via the cutaneous or respiratory systems also.
• Once in the host, the spores germinate and produce the vegetative form of the bacterium which rapidly proliferate.
• These rapidly dividing bacteria produce capsule and toxins. Early in the infection these toxins help the bacteria to evade the immune system resulting in systemic infection. Later in the infection with large numbers of bacteria in the blood, the toxins enter cells of other systems resulting in vascular shock and death.
• Late in the course of the disease and at death all animal excretions contain large numbers of bacteria and sporulate when contacting air. This exposes additional animals and contaminates the environment.

SIGNALEMENT
• Goats, sheep, cattle, and bison are more susceptible than other species such as horses, pigs, and dogs.

PHYSICAL EXAMINATION FINDINGS
• Commonly animals will be found dead and clinical signs not observed.

• Clinical signs include fever up to 107°F (41.5°C), congested mucous membranes, excitement, depression, stupor, dyspnea, ataxia, muscle tremors, collapse, convulsions, and death. Younger animals will have less severe signs.
• If the animal lives long enough bloody diarrhea, hematuria, and localized swellings may be seen as well as abortion.
• To prevent contamination of the environment collection of blood sample from a superficial vein using a large gauge needle and syringe is recommended.
• Microscopic examination of blood smears, bacterial cultures, and PCR are a few of the examinations laboratories use to identify Bacillus anthracis.

TREATMENT

THERAPEUTIC APPROACH
Often no therapeutic approach is available as the disease is peracute. Sick animals treated with antibiotics (see “Drugs of Choice”).
including but not limited to penicillin and tetracycline. However, eliminating the bacteria may not increase survival: once the toxins have entered cells in sufficient quantity, they can still manifest their lethal effects.

CONTRAINDICATIONS

Because the Sterne strain vaccine must replicate to effectively stimulate an immune response, antibiotic treatment should not be given in conjunction with or shortly after the administration of vaccine in healthy animals. However, field conditions may dictate a combination of vaccine and antibiotics as a practical course of action.

FOLLOW-UP

EXPECTED COURSE AND PROGNOSIS

In ruminants the incubation period is 1–5 days and the course of the disease is from hours to 2 days and the usual outcome is death.

PREVENTION

• Affected premises are quarantined to prevent further spread of the disease.
• Consideration should be given to limiting access to suspected sources of exposure in affected herds. This may include moving livestock to a different pasture, fencing livestock away from low-lying water sources, where spores may recently have been exposed due to drought conditions, providing insect control, and proper disposal of affected carcasses.
• Hygiene and carcass disposal are of paramount importance in halting an outbreak and preventing future disease occurrence.
• Autolysis of the carcass destroys the vegetative forms of \( B.\ anthracis \) and, therefore, if carcasses are not opened up, the potential for contamination of the environment is minimized.

MISCELLANEOUS

AGE-RELATED FACTORS

There are some reports of males being more susceptible than females and older animals being more susceptible than young animals, but these probably reflect differences in grazing behavior rather than inherent differences in susceptibility.

ZOONOTIC POTENTIAL

Anthrax can infect humans and precautions should be taken to avoid contamination with infected animal tissues, contaminated animal products, and anthrax spores.

BIOSECURITY

• Once anthrax is diagnosed, the farm will be quarantined. No movement of animals on or off the premises should occur during the quarantine period.
• Animals surviving an outbreak may be moved to uninfected pastures or holding pens in order to reduce the possibility of additional cases.
• Scavenger and insect control is important to prevent the spread of the disease.

• All equipment, vehicles, and working facilities used in an outbreak must be cleaned and disinfected.

PRODUCTION MANAGEMENT

Vaccination of livestock is an important consideration in anthrax endemic areas.

ABBREVIATION

PCR = polymerase chain reaction

Suggested Reading


Authors Regg D, Neiger and Dustin Oedekoven

Consulting Editor Christopher C.L. Chase

Client Education Handout available online
**Artesmic Toxicosis**

**Overview**
- Artesmic is the second most common cause of heavy metal intoxication of cattle, after lead.
- Artesmic is still used in herbicides, defoliants, wood preservatives, and other products.
- Alternative products with lower toxicity and less environmental persistence are becoming progressively more available.

**Incidence/Prevalence**
- Unknown

**Geographic Distribution**
- Worldwide

**Systems Affected**
- Digestive
- Urinary

**Pathophysiology**
- Poisoning most often results from exposure to inorganic arsenic compounds contained in commercial products including herbicides, insecticides, and pressure-treated wood.
- Ingestion of soluble arsenic compounds results in distribution of arsenic to many organs, with tissues rich in oxidative enzymes being the most vulnerable to damage, including the lungs, liver, kidneys, endothelium, and gastrointestinal tract.
- Mechanism of toxicity is complex and includes disruption of the citric acid cycle, creating damage to metabolically active tissues.

**Historical Findings**
- Diliberation or occupational exposure to products containing arsenic

**Signalment**
- Any ruminant species of any age, breed, or gender can be affected.

**Physical Examination Findings**
- Signs typically reflect acute toxicity and can include sudden death.
- Signs of acute or subacute toxicosis occur within 3–12 hours of exposure and reflect shock associated with gastrointestinal and cardiovascular damage.
- Cyclic, dehydrated, weakness, anorexia, and severe watery diarrhea, which may be hemorrhagic, are observed.

**Genetics**
- N/A

**Causes and Risk Factors**
- Exposure or access of animals to arsenic-containing products or residues such as herbicides, insecticides, and the ashes of pressure-treated wood.
- Grazing animals in areas of high environmental contamination which can result from residue from livestock dip, mining waste, and sources of industrial contamination.
- Ruminants are particularly sensitive to the aliphatic arsenicals MSMA and DSSA which are used as herbicides.

**Diagnosis**

**Differential Diagnosis**
- Bovine viral diarrhea virus (BVDV) could take effect.
- Bacterial enteritis (Salmonella spp.)
- Organophosphate insecticide exposure
- Other heavy metal toxicoses (lead)
- Urea toxicosis

**CBC/Biochemistry/Urinalysis**
- Changes are not specific to arsenic toxicosis, but are consistent with dehydration, shock, gastrointestinal damage, and hemorrhage.

**Other Laboratory Tests**
- Arsenic concentration can be chemically determined in tissues including the liver and kidney (>0.25 ppm potentially toxic) or feedstuffs for veterinary analysis.
- Arsenic can be measured in gastrointestinal contents and blood for 24–48 hours after poisoning, and for several days in urine.
- Chemical determination of arsenic in food (>0.25 ppm potentially toxic) or feedstuffs can be performed.
- Skin or hair can be tested in animals exposed for more than 2 weeks.

**Imaging**
- N/A

**Other Diagnostic Procedures**
- N/A

**Pathologic Findings**
- Gross findings include pale, swollen liver and kidneys, and generalized or localized reddening of the gastrointestinal mucosa with hemorrhage, erosions, submucosal edema, and blood in the mesenteric lymph nodes.
- Histopathologic findings include hepatic and renal tubular necrosis, dilation of intestinal capillaries, submucosal congestion and edema, and intestinal epithelial necrosis.

**Treatment**

**Therapeutic Approach**
- Recently exposed animals may benefit from maneuvers to reduce further ingestion and absorption of arsenic from the gastrointestinal tract.
- Effective treatment of clinically affected animals relies on supportive medical care in addition to targeted chelation therapy.
- Fluid support and blood transmutation may be required in severely affected animals.

**Surgical Considerations and Techniques**
- N/A

**Medications**

**Drugs of Choice**
- Absorption from the rumen after recent ingestion may be reduced via administration of mineral oil, or by rumen or rumenotomy.
- Chelation therapy can be attempted using:
  - Thiocetic acid (lipoic acid)—50 mg/kg, IM, q4h (20% solution divided into two to three injection sites).
  - Thiocetic acid should be used in combination with dimercaprol at 3 mg/kg, IM, q4h for 2 days, q6h on day 3, then q24h for 10 days. Dimercaprol is also known as British anti-lewisite (BAL) and is recommended for treating trivalent inorganic or aliphatic organic arsenic toxicity.
  - Sodium thiosulfate—IV: 30–40 mg/kg, PO: 20–30 g in 300 mL water (cattle) or 5–7 g in sheep and goats given q12h or q8h for 3–4 days.
  - d-penicillamine may be cost prohibitive—10–50 mg/kg, PO, q8h–q12h for 3–4 days.
  - 2,3-dimercaptopropanoic acid (DMSA; a water-soluble analog of dimercaprol)—10 mg/kg, PO, q8h has been recommended in small animals.

**Contraindications**
- N/A

**Precautions**
- The source of arsenic exposure should be identified to reduce human risk.
- Cases should be disposed of carefully to avoid environmental contamination.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

**Possible Interactions**
- N/A

**Precautions**
- The source of arsenic exposure should be identified to reduce human risk.
- Cases should be disposed of carefully to avoid environmental contamination.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

**Possible Interactions**
- N/A
FOLLOW-UP
EXPECTED COURSE AND PROGNOSIS
Death can occur within the first 3–5 days of clinical signs; surviving animals may demonstrate slow recovery over several weeks.
POSSIBLE COMPLICATIONS
- Bacteremia/septicemia from severe gastrointestinal damage
- Renal failure
CLIENT EDUCATION
Avoid access by ruminants to heavy metals.
PATIENT CARE
Fluid and nutritional support, and nursing care are indicated to optimize survival.
PREVENTION
Avoid access by ruminants to heavy metals.

MISCELLANEOUS
ASSOCIATED CONDITIONS
- Colic
- Renal failure
- Anemia
AGE-RELATED FACTORS
N/A

ZOONOTIC POTENTIAL
N/A
PREGNANCY
Pregnant animals may abort.
BIOSECURITY
N/A
PRODUCTION MANAGEMENT
N/A
SYNONYM
N/A
ABBREVIATIONS
- BAL = British anti-lewisite
- BVDV = bovine viral diarrhea virus
- DMPS = 2, 3-dimercaptosuccinic acid
- DMSA = disodium methane arsenate
- MSMA = monosodium methane arsenate

SEE ALSO
Toxicology: Herd Outbreaks

Suggested Reading


Author
Marianne Polunas
Consulting Editor
Erica C. McKenzie
Acknowledgment
The author and book editors acknowledge the prior contribution of Joe Rodier.
Arthrogryposis

Overview
Arthrogryposis is not a specific diagnosis, but rather a clinical finding of congenital contractures; these may be present in numerous disorders.

Congenital arthrogryposis ("crooked joint") is defined as a syndrome of persistent joint flexure or contracture present at birth and may involve one or multiple limbs (forelimbs and/or hindlimbs).

The capral and palmaral joints are most commonly affected, followed by metacarpophalangeal and metatarsophalangeal joints.

Arthrogryposis is often associated with cleft palate and primary CNS lesions such as hydrocephaly and syringomyelia. Severely affected animals may also have scoliosis, kyphosis, and torticollis; with rotation, abduction, or curled limbs.

The arthrogryposis-hydantocnephaly syndrome (AHS) is usually associated with flexural contracture of the limbs rather than angular limb deformities (ALDs).

In contrast with contracted tendons, arthrogryposis involves improper articular alignment or rotational deformity.

Crooked calf disease (CCD) is a congenital deformity condition widely recognized in western North America, characterized by arthrogryposis, scoliosis, torticollis, and cleft palate. CCD is observed in calves after maternal ingestion of lupines containing the quinolizidine alkaloid anagyrine during gestation days 40–100.

Congenital arthrogryposis may be associated with denervation muscle atrophy.

The terms "arthrogryposis multiplex congenita" and "congenital arthritic rigidity" have been introduced to describe cases in which the rigidity may be due to lack of extensibility of muscles, tendons, ligaments, or other tissues around the joint, or to deformity of articular surfaces, or to fusion between bones at the articular surface.

Incidence/Prevalence
For CCD, there are reports of up to 40% of calves from a single herd being affected. The incidence of disease varies with year, area, and herd.

Cattle records reveal that the disease usually affects <10% of a herd.

Geographic Distribution
Arthrogryposis is thought to occur worldwide. Depending on the etiologic cause and based on the distribution of vectors, viruses, and plants, the geographic distribution of individual syndromes may vary (e.g., CCD is most common in western North America).

General
Arthrogryposis has been reported from most parts of the world and in many breeds of cattle.

Systems Affected
Musculoskeletal

Pathophysiology
Congenital arthrogryposis is considered multifactorial in origin and has multiple predisposing factors and etiologies, including inherited defects. The causes are often not clear.

Can be caused by a number of etiologic agents including: plant teratogens, spinal dysraphism, prenatal viral infections that affect the nervous system, and in utero hormonal and vascular defects.

May also be attributed to a decrease or lack of motion of the fetus during critical stages of development, such as malpositioning and overcrowding caused by the size of the fetus relative to the dam.

Ingestion of teratogenic plants such as Astragalus or Oryzopsis spp. (locoweed); Verratrum californicum (skunk cabbage); piperidine alkaloid-containing plants such as Lupinus, Canaan, and Nicotiana species.

Reproduced during or continuous low-level ingestion over time may result in cumulative intoxication and/or teratogenesis.

Teratogenic plant alkaloids may be transferred to the placenta and induce a sedative or anesthetic effect in the fetus.

In CCD, there is often a lesion in the CNS that may result in reduced or absence of movement of the affected body parts in the developing fetus, especially during the period of rapid growth. Alpha-motor neurons in the developing fetus, especially during the period of rapid growth. Alpha-motor neurons in the spinal cord are significantly reduced.

May cause disruption in normal innervation of muscles leading to paralyzation and instability of the limb, or may result in hypotonic condition of extensor muscle and dysfunction of the radial nerve.

Historical Findings
A complete history including age, birthdate, details, age at which the deformity was noticed, course and progression of deformity, diets of affected animal and dam should be obtained. The animal may be normal at birth and develop the flexural deformity within hours or days.

Signalment
Species
Bovine, ovine, caprine, and camelid species

Breed Predilections

Genetics
Some genetic patterns have been worked out, for example, the arthrogryposis multiplex anomaly of Angus cattle is thought to be a simple autosomal recessive pattern.

S Syndromes found in Charolais, Finnish, Swedish, and Red Danish breeds of cattle are consistent with a simple recessive or modified recessive characteristic.

Dominant defect traits are inherited as well and are sometimes selected for.

Lamb: A congenital arthrogryposis exists in pedigree Suffolk and Australian Merino lambs as an inherited limb deformity.

Causes and Risk Factors
A number of etiologic agents such as intravascular agents such as BVDV, Akabane virus, Cache Valley virus, blue tongued virus, Aino virus, Kauba (Chuang) virus, Rift Valley Fever virus, Schmallenberg virus, and Wesselsbron virus, as well as teratogenic plant ingestion have been implicated in the pathogenesis of arthrogryposis in ruminants.

Congenital Predisposing Factors
Uterine malpositioning

Genetic causes
Ingestion of teratogenic plants by pregnant dam such as Astragalus or Oryzopsis spp. (locoweed); Verratrum californicum (skunk cabbage); piperidine alkaloid-containing plants such as Lupinus, Canaan, and Nicotiana species.

Conditions associated with arthrogryposis include CCD/congenital arthrogryposis, HC (hereditary chondrodysplasia or spider lamb...
syndrome), ill-thrift syndrome in llamas, metabolic, and neurovascular disorders.

- Leg deformities in young calves are most commonly associated with congenital contraction of the tendons. External deformities involving contracted tendons and ligaments may be seen in many breeds of cattle and small ruminants.

**Risk Factors**

Predisposing factors for congenital arthrogryposis include male calves, posterior intrauterine presentation, and double muscling.

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### DIAGNOSIS

**DIFFERENTIAL DIAGNOSES**

- Arthrogryposis and CCD differ from contracted tendons; in animals with contracted tendons, the joints are usually properly aligned and the legs are not rotated. In calves with arthrogryposis, the articular cartilage and ossusus changes are usually permanent and worsen as the calf grows.
- Fracture malunion.
- See “Causes and Risk Factors” (viruses and toxic plants).
- Arthrogryposis-hydramniosphaphy syndrome (AHS) in lambs may be confused with HC.

**CBC/BIOCHEMISTRY/URINALYSIS**

N/A

**OTHER LABORATORY TESTS**

N/A

**IMAGING**

- Radiographs can be used to diagnose ALDs; at least two views, 90 degrees apart, should be taken of the affected joint.
- The dorsoplantar/dorsoplantar (DP) view is needed for examination of the anatomic location of the deformity and for measurements. Shoot with radiographic beam in line with the claws.

**OTHER DIAGNOSTIC PROCEDURES**

- Stenography and virologic diagnostic assays may be ruled in ruling out an acute viral infections (e.g., Cache Valley virus).
- Feed analysis and assessment of the availability of potentially toxic plants in the environment (pasture) may assist in diagnosis.

**PATHOLOGIC FINDINGS**

- No consistent primary lesion in CCD; a number of varied tissue responses are observed. It is likely that these findings are at least in part due to the animal’s immaturity to stand.
- CCD histology: Few lesions, restricted to muscles of the forelimb, external intercostalis muscle, or radial and femoral nerves—myositis, myodegeneration, muscle necrosis and atrophy, cellulitis, and perineuritis.

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### TREATMENT

**THERAPEUTIC APPROACH**

- Severely affected animals may be unable to rise to nurse and require additional supportive care.
- Protect limbs with thick, soft bandages that do not restrict blood flow. Minor deformities may be corrected by manual alignment and external support of the limb (e.g., rigid splinting, bandaging, or casting/tube casts).
- Provide good footing and allow for stretching of flexor tendons.
- Maintain a soft (padding), clean, and dry environment to minimize decubital/pressure sores, open arthritis, muscle atrophy, umbilical infections, and septicaemia.
- Restrict activity until it is certain that the deformity is improving; however, some degree of exercise allows for stretching and lengthening of affected limb structures.
- Weight bearing provides the necessary physical exercise to strengthen and lengthen affected tendons and musculature.
- Dietary imbalances should be addressed while treating cases of arthrogryposis.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

- Surgery may be required for animals with severe deformities and for animals that do not improve with age or conservative management.
- Treatment of arthrogryposis includes surgery to improve the animal’s posture sufficient for it to obviate slaughter weight (a salvage procedure).
- Surgical procedures include transection of flexor tendon and suspensory ligament, joint capsule release, flexor tendon lengthening procedures, and joint arthrodesis.
- May require postoperative splinting or casting for support.

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### MEDICATIONS

**DRUGS OF CHOICE**

N/A

**CONTRAINDICATIONS**

N/A

**PRECAUTIONS**

N/A

**POSSIBLE INTERACTIONS**

N/A

**ALTERNATIVE DRUGS**

N/A

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### FOLLOW-UP

**EXPECTED COURSE AND PROGNOSIS**

- The prognosis is guarded, depending on the severity of the flexural deformity. Severe deformities requiring surgery often have a poor prognosis.
- For arthrogryposis in cattle, approximately 80% of surgically treated animals can be kept until they reach normal slaughter weight.

**POSSIBLE COMPLICATIONS**

- Some severe cases of arthrogryposis cannot be corrected and full extension may not be possible postoperatively.

**CLIENT EDUCATION**

- Examination of young animals with congenital arthrogryposis should be done as early as possible to assess the degree of manual correction possible.
- Because of a possible hereditary component associated with some forms of arthrogryposis, breeding of affected animals is not recommended.
- Many affected animals are stillborn or die shortly after birth. Others may fail to thrive and euthanasia should be considered.

**PATIENT CARE**

Frequent physical examinations and assessing the efficacy of corrective measures should be done to monitor progress.

**PREVENTION**

- CCD/HC: Avoid breeding affected animals.
- Coordinate grazing times and alter breeding rates to minimize exposure. Avoid grazing potentially teratogenic plants when pregnant cows are at the susceptible stage of pregnancy.
- Control teratogenic plant populations with herbicides.

**ASSOCIATED CONDITIONS**

- Arthrogryposis, a syndrome known as “bentleg” in llamas or “bowie” in cattle, has been associated with ingestion of *Eupatorium glaucifolium* (wild parsnip) by pregnant ewes in Australia and New Zealand.

**AGE-RELATED FACTORS**

- Majority of cases occur during the active growth phase of the affected bone/joint.

**ZOONOTIC POTENTIAL**

N/A

**PREGNANCY**

In cases of congenital arthrogryposis, the teratogenic plants are ingested by the pregnant dam and the compounds are passed to the fetus through the placenta.

**BIOSECURITY**

N/A
PRODUCTION MANAGEMENT
• Producers should be aware of the association between certain toxic plants (e.g., lupines) and angular limb deformities such as CCD.
• To reduce the incidence of CCD, graze lupines during their least hazardous growth period and reduce exposure of pregnant cows. Lupines are most hazardous when they are young or in the mature seed stage.
• Fence off heavily infested pasture areas and use intermittent, short-term grazing of lupine pastures.

SYNONYMS
N/A

ABBREVIATIONS
• AHS = arthrogryposis-hydranencephaly syndrome
• ALD = angular limb deformity
• BVDV = bovine viral diarrhea virus
• CCD = crooked calf disease/syndrome
• CNS = central nervous system
• DP = dorsopalmar/dorsoplantar
• HC = hereditary chondrodysplasia
• IBR = infectious bovine rhinotracheitis virus

SEE ALSO
• Akabane
• Angular Limb Deformities

Brain Assessment and Dysfunction (see www.fiveminutevet.com/ruminant)
• Cache Valley Virus
• Lameness: Bovine
• Lameness: Camelid
• Lameness: Small Ruminants
• Lupine Toxicity
• Schmallenberg Virus
• Weselbron Disease

Suggested Reading
Panter, K.E., Keeler RF, Bunch TD, Callon RJ. Congenital skeletal malformations and cleft palate induced in goats by ingestion of Lupinus, Conium, and Nicotiana species. Toxicon 1990, 28: 1377–85.

Authors Erik J. Olson and Nicholas A. Robinson
Consulting Editor Kaitlyn A. Lutz
Acknowledgment The authors and book editors acknowledge the prior contribution of Cathy S. Carlson.
Artificial insemination (AI) is the aseptic semen collection and cryopreservation of bulls for use in reproduction. Artificial insemination (AI) is the aseptic semen collection and cryopreservation of bulls for use in reproduction. Artificial insemination (AI) is the aseptic semen collection and cryopreservation of bulls for use in reproduction.

SEMIN COLLECTION AND CRYOPRESERVATION

Electroejaculation

Semen used for AI is commonly collected using an artificial vagina (AV) (most common in commercial AI bull centers) or by electroejaculation (custom freezing of bulls not trained to an AV, salvage of genetics from terminally ill bulls). Epididymal spermatozoa may be collected to salvage genetics from bulls following castration, injury or terminal illness. Semen collected with an AV presents better post-thaw motility than semen collected with electroejaculation.

Although fresh/cooled semen may be used in some ranches, most AI in the bovine uses frozen-thawed semen. Semen is frozen after dilution in various commercial extenders in the presence of antibiotics, egg yolk, and glycerol. Bovine sperm is usually frozen in 0.25 or 0.5 mL straws. The majority of sex-sorted (gender-selected) semen is packaged in 0.25 mL straws.

In general, the total dose per straw is 10 to 20 million motile spermatozoa. However, this dose is considerably lower for elite bulls and sex-sorted semen. Higher doses are used for bulls with lower fertility or in custom freezing of beef bulls.

The cryopreservation process varies slightly depending on extender and technique used. The cryopreservation process varies slightly depending on extender and technique used. The cryopreservation process varies slightly depending on extender and technique used.

Factors Affecting AI Success

Quality of Semen

The quality of frozen-thawed semen depends on initial quality at production, handling during storage, thawing procedures, and interval until deposition into the uterus. This can occur during handling or transfer of straws between tanks or may be due to faulty processing used for cryopreservation.

Repealed exposure to temperature above −80°C may cause changes in liquid/frozen phase and damage to the sperm membrane. This can occur during handling or transfer of straws between tanks or may be due to faulty handling during storage, thawing procedures, and interval until deposition into the uterus.

The quality of frozen-thawed semen depends on initial quality at production, handling during storage, thawing procedures, and interval until deposition into the uterus. This can occur during handling or transfer of straws between tanks or may be due to faulty handling during storage, thawing procedures, and interval until deposition into the uterus.

Quality at production is affected by initial quality of the ejaculate, method of collection used, the inherent freezability, and methods of processing used for cryopreservation.

Additional factors that affect post-thaw motility include: temperature, pH, osmolality, concentration of extender, and concentration and interval until deposition into the uterus. This can occur during handling or transfer of straws between tanks or may be due to faulty handling during storage, thawing procedures, and interval until deposition into the uterus.

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- Temperature
- pH
- Osmolality
- Concentration of extender
- Concentration and interval until deposition into the uterus

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Temperature

Thawing at high temperatures may be very difficult to observe in field conditions.

- Thawing procedures should be strictly observed.
- Check water baths for temperature control accuracy.
- Use a stopwatch for the timing of thawing.
- In cold areas, it is preferable to keep straws in the water bath, at 35°C, until use.
- Prevent exposure of the straw to low temperatures after thawing: use a pre-warmed insemination gun; protect prepared gun from exposure to low temperature.
- Thaw out straws and prepare insemination guns in a sheltered area when ready to inseminate.
- Clean and dry straws before loading in the AI gun.
- Straws should be cut using straw cutters to prevent backflow of semen during insemination.
- Time period from removal of straw from the tank to insemination should not exceed 15 minutes.

Timing of Insemination

- Insemination timing is important to maximize conception rates. Ovulation occurs 28–32 hours after the beginning of estrus.
- Optimum fertility of the oocyte is 6–12 hours after ovulation and the viable lifespan of spermatozoa in the reproductive tract is estimated to be between 24 and 30 hours.
- The optimal time for insemination is 12 hours after first observed estrus. This has led to the AM/PM rule: if a cow is observed in estrus in the morning she is inseminated in the afternoon, and vice versa.
- Several schemes for timed insemination have been developed.
- Double insemination at a 12-hour interval is sometimes performed in cows with decreased fertility, when using semen straws with lower concentration, or in cows that have been superstimulated for embryo collection.

Insemination Technique

- Semen should be deposited at the proper site without excess manipulation.
- People who inseminate cows periodically cannot achieve a high level of expertise.
- Semen is deposited in the body of the uterus by transeptal manipulation of the insemination gun for cervical catheterization.
- Deep horn insemination may reduce conception rates in the hands of untrained people due to irritation of the uterus.
- Deep utricle insemination may be important when low spermatozoa numbers are used (i.e., sexed semen).
- Good inseminators should be able to pass the cervix rapidly and with a high degree of reliability. Cervical catheterization is particularly difficult in some breeds of cattle (e.g., Santa Gertrudis).
### Artificial Insemination: Bovine

**A**

**PRECAUTIONS**
N/A

**POSSIBLE INTERACTIONS**
N/A

**ALTERNATIVE DRUGS**
N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
- Pregnancy rates depend on many factors: breed, quality of semen, site of semen deposition, nutrition, milk production (dairy), environmental conditions, parity, type of synchronization program, and human factors.
- Conception rates following artificial insemination range between 60 and 50% in cows and 60 to 70% in heifers. However, in dairy cattle, pregnancy rates 15 to 40 days following AI are generally between 20% and 50% due to a high early embryonic loss.
- In addition to the factors already mentioned, other factors involved in decreased conception rate in dairy cows are:
  - Immunization of non-estrous cows
  - Heat stress prior to artificial insemination
  - Incidence of postpartum diseases
  - Clinical mastitis

**POSSIBLE COMPLICATIONS**
- Perforation of the vagina or uterus by the inseminator’s hand.
- Insemination of non-estrous cows.
- Heat stress prior to artificial insemination.

**PATIENT CARE**
- Appropriate estrus detection and handling to reduce stress.
- Prevent stress.

**POSSIBLE INTERACTIONS**
N/A

**PREVENTION**
N/A

**MISCELLANEOUS**

**ASSOCIATED CONDITIONS**
N/A

**AGE-RELATED FACTORS**
- Normal conception rates have been achieved with as low as 2 million spermatozoa in heifers.

**ZOONOTIC POTENTIAL**
- See “Expected Course and Prognosis”

**BIOSECURITY**
- Use semen from bulls routinely tested for brucellosis, IBR, BVD, trichomoniasis, and campylobacteriosis, as well as bluetongue virus (Certified Semen Service).
- Bacteriologic quality of semen is ensured by strict hygiene during collection and use of specific guidelines for antimicrobials in the extenders (Certified Semen Service).
- All straws are properly labeled, identifying the semen center, bull, breed, and date on which semen was collected.

**PRODUCTION MANAGEMENT**
- Use a professional inseminator.

**SYNONYMS**
N/A

**ABBREVIATIONS**
- AI = artificial insemination
- AV = artificial vagina
- BVD = bovine viral diarrhea
- CL = corpus luteum
- EBR = infectious bovine rhinotracheitis
- LN = liquid nitrogen
- NAAB = National Association of Animal Breeders

**SEE ALSO**
- Beef Bull Management (see www.fiveminutevet.com/ruminant)
- Estrus Synchronization: Bovine
- Reproductive Pharmacology
- Reproductive Ultrasonography: Bovine (see www.fiveminutevet.com/ruminant)

**Suggested Reading**
- Ahmed Tibary, Paul E Mennick, and John Gibbons.

**INFORMATION SOURCES**
- Ahmed Tibary, Paul E Mennick, and John Gibbons.

**ACKNOWLEDGMENT**
The author and book editors acknowledge the prior contribution of Ahmed Tibary, Paul E Mennick, and John Gibbons.
laparoscopically. Cervix, insemination is performed deposited into the uterine cavity. Of semen deposition. Ideally, preserved semen fertilization rates depends on quality and site insemination required for adequate estrus. Performed within 12 hours after onset of beyond 12 hours post-ovulation. AI should be achieving acceptable fertilization rates. Reduces sperm viability. Therefore, timing and addition, processing and cryopreservation significantly lower than in natural mating. In morphologically normal sperm is found in the uterus and only highly motile, the cervix after natural mating. Sperm is fertilization site, and proper timing in of semen, adequate transport to the of estrus.

Reproductive Worldwide

GEOGRAPHIC DISTRIBUTION

Systems Affected Reproductive

Pathophysiology

• Adequate fertilization rates are achieved when sperm form a reservoir at the level of the isthmus of the uterine tube and remain viable until ovulation occurs.
• Fertilization rates are dependent on quality of semen, adequate transport to the fertilization site, and proper timing in relationship to ovulation.
• In small ruminants, semen is deposited onto the cervix after natural mating. Sperm is selectively transported through the cervix into the uterus and only highly motile, morphologically normal sperm is found in the isthmus.
• With AI the number of sperm used is significantly lower than in natural mating. In addition, processing and cryopreservation reduce sperm viability. Therefore, timing and site of deposition of sperm are critical in achieving acceptable fertilization rates.
• Sperm viability is extremely reduced beyond 12 hours post-ovulation. AI should be performed within 12 hours after onset of estrus.
• The number of viable spermatozoa per insemination required for adequate fertilization rates depends on quality and site of semen deposition. Ideally, preserved semen (chilled or frozen-thawed) should be deposited into the uterine cavity.
• In sheep and small breeds of goats, TCI is limited by the morphology of the sheep cervix, which is long, tortuous, and narrow, with nonconcentric rings. However, several techniques have been proposed to improve TCI in sheep; these include the use of special catheters for restraint, and the use of flexible AI guns.
• Laparoscopic—Semen is injected directly into the uterus via laparoscopic port(s). Between 20 and 40 million sperm are required (15–20 million if sex-sorted).

Method of Insemination

• Blind vaginal insemination—At least 400 million sperm are blindly deposited around the external cervical os. This technique is useful only when fresh, extended semen is used.
• Intracervical—At least 200 million sperm are deposited into the cervical canal as far as the AI gun can advance.
• TCI—Between 50 and 100 million spermatozoa are required. TCI is used more in goats as the cervix is more easily catheterized. In sheep, TCI is limited by the morphology of the sheep cervix, which is long, tortuous, and narrow, with nonconcentric rings. However, several techniques have been proposed to improve TCI in sheep; these include the use of special catheters for restraint, and the use of flexible AI guns.
• Laparoscopic—Semen is injected directly into the uterus via laparoscopic port(s). Between 20 and 40 million sperm are required (15–20 million if sex-sorted).

Drawbacks to this technique include the need for sedation or anesthesia of the animal, laparoscopic equipment, increased labor time and costs, and postoperative monitoring.

Genetics

AI is the best method for rapid genetic improvement of a flock or herd.

Causes and Risk Factors

N/A

Diagnosis

DIFFERENTIAL DIAGNOSIS

N/A

CBC/BIOCHEMISTRY/URINALYSIS

N/A

Other Laboratory Tests

Semen analysis

Imaging

Transrectal or transluminal ultrasonography for pregnancy diagnosis following artificial insemination.

Other Diagnostic Procedures

Pregnancy diagnosis using serum concentration of pregnancy associated glycoproteins.

Pathologic Findings

N/A
ARTIFICIAL INSEMINATION: SMALL RUMINANT

(continued)

**TREATMENT**

**THERAPEUTIC APPROACH**
- Estrus should be synchronized using approved hormonal methods of synchronization.
- Several treatments (oxytocin, estrogen, β-adrenergic blocking agents, relaxin, and PGE) have been used in sheep to induce cervical relaxation for TCI but were not very successful.

**SURGICAL CONSIDERATIONS AND TECHNIQUE**
- Estrous animals displaying systemic illness should not be selected for surgical insemination. Obese and non-fasted animals present surgical challenges.
- Animals should be fasted for 18–24 hours prior to laparoscopic AI (LAI).
- LAI is performed under sedation and local block in sheep. Heavy sedation or general anesthesia is preferred in goats. The animal is placed in dorsal recumbency on a cradle in a Trendelenburg position. The ventral abdomen is clipped and prepared for surgery.
- Two portals are created on each side (about 5 cm) of the linea alba and about 6–10 cm from the cranial border of the mammary gland. The laparoscope is inserted into the abdominal cavity from one portal. The uterus is visualized and the insemination gun is inserted through the other portal using a cannula. The uterus is stabbed with the needle of the insemination gun and semen is deposited in the lumen.
- Insemination laparoscopically is recommended. The uterine horn is stabbed with the needle of the insemination gun and semen is deposited in the lumen.
- Skin incisions are usually closed with staples or absorbable suture.

**MEDICATIONS**

**DRUGS OF CHOICE**
- Sedation and anesthesia: xylazine and ketamine.
- Administration of antibiotics and anti-inflammatories is recommended.

**CONTRAINDICATIONS**
- Appropriate milk and meat withdrawal times must be followed.

**PRECAUTIONS**
- N/A

**POSSIBLE INTERACTIONS**
- N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
- Pregnancy rates depend on many factors: species and breed, type of semen used, extender type, site of deposition of semen, nutrition, season, environmental conditions, parity, the synchronization program used, and human factors.
- Expected conception rates when semen quality and number of spermatozoa are adequate are:
  - Vaginal AI: fresh semen 60–75%; frozen semen 5–30%
  - Intracervical AI: fresh semen 50–80%; frozen semen 35–60%
  - TCI: fresh semen 40–80%; frozen semen 30–70%
  - Laparoscopic AI: fresh semen 40–80%; frozen semen 40–70%

**POSSIBLE COMPLICATIONS**
- For surgical complications see “Patient Care”.
- TCI in sheep may result in cervical trauma or laceration.

**CLIENT EDUCATION**
- Clients should be aware of factors affecting fertility and the expected pregnancy rates for the type of semen and AI used.

**PATIENT CARE**
- Animals should be handled with minimal stress.
- After laparoscopic AI, animals should be monitored for complications, including inoculation injury or dehiscence, fever, peritonitis, and adhesion formation. Animals should be vaccinated against Clostridium species. Administration of antibiotics and anti-inflammatories is recommended.
- Pregnancy diagnosis should be performed after an AI program.

**PREVENTION**
- N/A

**ASSOCIATED CONDITIONS**
- N/A

**AGE-RELATED FACTORS**
- TCI is more difficult in young maiden females.

**ZOONOTIC POTENTIAL**
- N/A

**PREGNANCY**
- N/A

**BIOSECURITY**
- All males used for semen collection and AI should have a health screening and infectious disease testing prior to use.
- Hygienic semen collection and processing of semen should be performed according to guidelines described by the Office International des Epizooties.
- Diseases that can be transmitted by semen include: Bluetongue, Border disease, brucellosis, leptospirosis, paratuberculosis, Q fever, contagious caprine pleuropneumonia, ovine enzootic abortion, Lentivirus infection, paste des petits ruminants, Salmonella serotype abortionis, and goat pox.

**PRODUCTION MANAGEMENT**
- AI with fresh semen allows more efficient use of top sires, particularly after synchronization of estrus.
- Use of frozen semen allows genetic improvement.
- AI after a synchronization program can allow predictable parturition dates and allow segregation of animals on the farm by physiologic status.
- AI can allow for accelerated lambing programs or out-of-season breeding.

**SYNONYMS**
- N/A

**ABBREVIATIONS**
- AI = artificial insemination
- PGE = prostaglandin E
- TCI = transcervical insemination

**SEE ALSO**
- Estrus Synchronization: Small Ruminants

**Suggested Reading**

**Author** Lisa Pearson

**Consulting Editor** Ahmed Tibary

**Acknowledgment** The author and book editors acknowledge the prior contribution of Ahmed Tibary.
Respiratory uncommon sequela. Secondary bacterial infection is a associated with nondegradable foreign material. Secondary bacterial infection is a common sequela.

INCIDENCE/PREVALENCE

Uncommon

GEORGIC DISTRIBUTION

N/A

SYSTEMS AFFECTED

Respiratory

PATHOPHYSIOLOGY

• The disorder often arises following the accidental or forceful administration of substances and medication by unskilled personnel, or after inappropriate regurgitation aspiration associated with heavy sedation, anesthesia, or oropharyngeal and esophageal disorders.

• Lung tissue in the cranioventral thorax is most commonly affected after inhalation or instillation of a foreign substance.

• The affected lung tissue is irritated, inflamed, and loses capacity for appropriate clearance, immune function, and oxygenation. Secondary bacterial infection frequently occurs.

HISTORICAL FINDINGS

Consistent with a primary illness or management activity prompting treatment with oral medications or substances, or preexisting signs of upper gastrointestinal dysfunction.

SIGNALMENT

• Varies with different inciting conditions.

• Young ruminants and crias may suffer aspiration from accidental or forced inhalation during provision of colostrum or milk, from inhalation of meconium in fetal fluids during difficult parturition; from poorly performed bottle feeding; from congenital disorders such as cleft palate and atrial septal defect; and from acquired disorders such as selenium deficiency and necrotic laryngitis.

• Mature ruminants and camels may suffer aspiration due to pharyngeal and esophageal dysfunction related to trauma, abscessation, choke, or megaesophagus; infectious diseases (botulism, listeriosis); heavy sedation or anesthesia; toxicosis (ingestion of lead, crude oil, fuel oil, natural gas condensate, rhododendrin); and from oral medication administration or severe hypocalcemia (lactating cattle).

PHYSICAL EXAMINATION FINDINGS

• Acute-onset depression, tachypnea, coughing, and fever.

• Large volume aspiration can produce dyspnea, tachypnea, tachycardia, nasal discharge, and malodorous breath.

• Thoracic auscultation can reveal adventitious lung sounds, plural friction rub or reduced audibility of ventral lung sounds if pleural fluid accumulates.

• Shock and sudden death may occur.

• Milk or feed material may be seen coming from the nostrils in cases where dysphagia or esophageal disorders are the initiating cause.

GENETICS

N/A

CAUSES AND RISK FACTORS

• Accidental or forceful administration of substances and medication orally or oraeographically by unskilled personnel.

• Heavy sedation or general anesthesia.

• Oropharyngeal and esophageal disorders.

• Submersion dipping of livestock.

• Exposure to poorly cured silage (lactating cattle).

IMAGING

• Radiographs typically show alveo-interstitial pattern that is most pronounced in the cranioventral lung fields. Pleural fluid lines or pulmonary abscesses may be evident.

• Ultrasonography reveals cranioventral consolidation with or without pleural effusion.

• Thoracography reveals bronchoconstriction and pleural adhesions.

• Bronchographic findings can be performed if indicated.

OTHER LABORATORY TESTS

N/A

MEDICATIONS

DRUGS OF CHOICE

• Broad-spectrum antibiotic therapy is indicated to cover Gram positive and Gram-negative bacterial agents. In severe cases anerobic bacterial coverage is also indicated.

• Appropriate antibiotic coverage can be achieved using combinations of antibiotics, or one antibiotic depending on the desired spectrum and duration of coverage; drugs should be given at recommended doses and dosing intervals.

CONTRAINDICATIONS

Oral administration of medications during treatment is likely contraindicated if infection in pharyngeal and esophageal function are present.
Aspiration Pneumonia (Continued)

PRECAUTIONS
Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

POSSIBLE INTERACTIONS
N/A

FOLLOW-UP
EXPECTED COURSE AND PROGNOSIS
• Animals with relatively minor aspiration events that receive prompt therapy are expected to survive.
• Aspiration events that are large volume, promote gangrenous pneumonia, have delayed recognition and treatment, or are associated with congenital or poorly reversible disorders have a poor prognosis.
• Fibrosing alveolitis (oil aspiration), pulmonary abscessation, and pulmonary granulomas are chronic sequelae that typically reduce prognosis.

POSSIBLE COMPLICATIONS
• Chronic respiratory disease related to fibrosing alveolitis or ongoing pulmonary inflammation and infection.
• Septicemia and multiorgan failure.

CLIENT EDUCATION
Personnel should be thoroughly instructed in the correct techniques for administering medications by mouth or orogastric tube.

PATIENT CARE
• Monitor for worsening of respiratory function, fever and any other associated clinical signs.
• Provide a soft and palatable ration.
• Intermittent orogastric feeding may be indicated for animals with upper gastrointestinal dysfunction.

PREVENTION
• Education regarding medication administration is the most important method of preventing aspiration events.
• Fasting of animals combined with careful head positioning, intubation during sedation and general anesthesia reduces the risk of inducing aspiration.

MISCELLANEOUS
ASSOCIATED CONDITIONS
N/A

AGE-RELATED FACTORS
Young animals are prone to aspiration events associated with feeding management, or with congenital disorders and selenium deficiency.

ZOOOTIC POTENTIAL
N/A

PREGNANCY
N/A

BIOSECURITY
N/A

PRODUCTION MANAGEMENT
• Avoid unnecessary oral medications and instruct personnel to deliver oral medications or drenches at a measured rate to allow the animal to swallow, with the head positioned level or down, and with great caution during periods of struggling and vocalization.
• Caustic or inflammatory substances (calcium chloride, mineral oil) are often best given by orogastric tube versus oral drench.

SYNONYMS
N/A

ABBREVIATIONS
N/A

SEE ALSO
• Atypical Interstitial Pneumonia
• Call Diphtheria/Necrotic Stomatitis
• Enzootic Pneumonia of Calves
• Respiratory Disease: Bovine
• Respiratory Disease: Canine
• Respiratory Disease: Small Ruminant

Suggested Reading

Author
Jeff Lakritz

Consulting Editor
Erica C. McKenzie
Ingestion of moldy sweet potatoes by cattle infected with the fungus *Fusarium solani*. The tall, green plants are found along the edge of wooded areas in pastures and grow well in late summer when other plants are dry. Intoxication commonly occurs in drought or feedstock forage is limited. Consumption of volatiles oil in these plants, including perilla ketone and two other substituted furans, results in comparable lung injury to 3-MI and 4-IP toxicity.

**AIP in feedlot cattle has not been fully elucidated but typically occurs in the late feeding period when animals have been consuming a high concentrate diet for some time. This is considered a multifactorial condition and specific features of feedlot ration and rumen metabolism may contribute to the formation of 3-MI and other metabolites. Mortality is highest in summer and fall, when on finishing diets. Heifers are far more susceptible than males which may relate to the use of melengestrol acetate to control estrus.**

**CAUSES AND RISK FACTORS**

- Movement of cattle from dry summer range onto irrigated or fertilized pastures in late summer in the southeastern USA (*Perilla frutescens*) and New Zealand (*Perilla scutellata*). The tall, green plants are found along the edge of wooded areas in pastures and grow well in late summer when other plants are dry. Intoxication commonly occurs in drought or feedstock forage is limited. Consumption of volatiles oil in these plants, including perilla ketone and two other substituted furans, results in comparable lung injury to 3-MI and 4-IP toxicity.

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**PHYSICAL EXAMINATION FINDINGS**

- Sudden onset of severe expiratory dyspnea. Collapse and sudden death can occur with exertion. Subcutaneous emphysema may occur.

**GENETICS**

- No breed predilection.

- Heifers are 3 times as likely to develop AIP in feedlot situations.

**CAUSES AND RISK FACTORS**

- Movement of cattle from dry summer range onto irrigated or fertilized pastures in fall.

- Feedlot environment and ration.

- Female gender (feedlot AIP).

- Mature age (>2 years).

- Feedlot environment and ration.

- Movement of cattle from dry summer range onto irrigated or fertilized pastures in late summer in the southeastern USA (*Perilla frutescens*), and New Zealand (*Perilla scutellata*). The tall, green plants are found along the edge of wooded areas in pastures and grow well in late summer when other plants are dry. Intoxication commonly occurs in drought or feedstock forage is limited. Consumption of volatile oil in these plants, including perilla ketone and two other substituted furans, results in comparable lung injury to 3-MI and 4-IP toxicity.

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Atypical Interstitial Pneumonia (Continued)

**CONTRAINDICATIONS**
N/A

**PRECAUTIONS**
- Any stress or exertion, including treatment, can precipitate fatal collapse.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

**POSSIBLE INTERACTIONS**
N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
- Most fatalities from toxic interstitial pneumonia are likely to occur in the first two days of clinical signs. Animals with severe disease may display chronic emphysema or signs of cardiac failure related to cor pulmonale.
- Moderately to mildly affected animals often improve substantially and spontaneously after 72 hours and continue to recover over 10 days.
- Feedlot AIP typically has a poor prognosis.

**POSSIBLE COMPLICATIONS**
Secondary bacterial pneumonia

**CLIENT EDUCATION**
Focus on preventive management factors relevant to the various disorders.

**PATIENT CARE**
- Exertion should be minimized; it is generally best to leave affected animals in their location and to provide alternative sources of safe feed (hay).
- Monitor progression of disease or improvement, so animals in severe distress can be euthanized before undue suffering occurs.

**PREVENTION**
- Management practices that prevent abrupt exposure of animals to suspect pasture can include gradually increasing pasture time over 10–12 days (commensuring with 2 hours/day); strip grazing; or using other species or young stock to graze pasture down before adult cattle. Delaying use of lush pastures until after a hard frost, or curting and windowing pasture before turning cattle out is also preventive.
- Prophylactic administration of monensin or lasalocid (200 mg/head/day) for 1 day or 6 days respectively, prior to placing adult cattle on lush pasture can prevent disease if maintained for at least 10 days after introduction to pasture. These drugs reduce the conversion of L-tryptophan to 3-MI.
- Provide sufficient feed and minerals during late summer to limit consumption of toxic plants.
- Do not feed moldy sweet potatoes to livestock.
- Fence off access to toxic plants.

**ASSOCIATED CONDITIONS**
- Secondary bacterial bronchopneumonia
- Viral respiratory infections

**AGsignature RELATED FACTORS**
Young animals are resistant.

**ZOOONOTIC POTENTIAL**
N/A

**PREGNANCY**
N/A

**BIOSECURITY**
N/A

**PRODUCTION MANAGEMENT**
Management has the greatest influence on the occurrence of these disorders, hence attention should be paid to minimizing all associated causes and risk factors, or where possible, employing specific preventive strategies.

**SYNONYMS**
- Fog fever
- Acute bovine pulmonary edema
- Pulmonary adenomatosis
- Acute respiratory distress syndrome

**ABBREVIATIONS**
- AIP = atypical interstitial pneumonia
- 3-MI = 3-methyl-indole
- 4-IP = 4-ipomeanol

**SEE ALSO**
Respiratory Disease: Bovine

**Suggested Reading**

Author: Jeff Lakritz
Consulting Editor: Erica C. McKenzie
**BASICS**

**OVERVIEW**
- There are approximately 150 species of avocado (*Persea*). Of these, *Persea americana* and its races and cultivars are of toxicologic importance. Races and cultivars most commonly encountered include Guatemalan and its hybrid (“Fuerte”), Mexican, and West Indies.
- The tree or shrub has a dense crown with brown to gray bark.
- Leaves, fruit, and seeds are toxic with leaves being the most toxic.
- Leaves alternate and crowd near the end of the twig. Leaf blades are ovate-elliptical with single primary vein.
- Flowers are perfect, greenish yellow.
- Fruit are ovoid to pyriform with thick glossy green to dark green skin.
- Seeds are large and light brown.

**GEOGRAPHIC DISTRIBUTION**
Cultivated primarily in Mexico, California and Florida, but can also be found as an ornamental in the Gulf coast areas.

**SYSTEMS AFFECTED**
- Mammary
- Cardiovascular

**PATHOPHYSIOLOGY**
- Suspected toxin is a R-enantiomer of persin. However, the mechanism of action is unknown.
- Toxin targets the mammary gland and myocardium depending on the amount of plant consumed.

**HISTORICAL FINDINGS**
Exposure to avocado groves

**SIGNALMENT**
Bovine, ovine, caprine (especially). Goats are highly susceptible to the mammary-induced effects of avocado poisoning, although all lactating animals can develop noninfectious mastitis and agalactia. With respect to cardiotoxic effects of avocado, all animal species are considered susceptible.

**PHYSICAL EXAMINATION FINDINGS**
- Mammary gland effects present as mastitis 24 hours post-ingestion with a 75% decrease in milk production. Milk appears to be watery and curdled.
- Myocardial effects present as edema of the neck and brisket, infrequent cough, depression, reluctance to move, leading to respiratory distress and cardiac arrhythmia.

**CAUSES AND RISK FACTORS**
- Presumed exposure to R-enantiomer of persin.
- Toxic dose:
  - Mammary effects are seen with ingestion of 20 g of fresh leaves/bwt (kg) in lactating goats.
  - Myocardial effects were seen with ingestion of:
    - 80 g of fresh leaves/bwt (kg) in lactating goats
    - 25 g fresh leaves/bwt (kg) for 5 days in sheep (severe signs)
    - 15 g fresh leaves/bwt (kg) for 21 days in sheep (chronic signs)
    - 2.5 g fresh leaves/bwt (kg) for 32 days in sheep (mild signs)

**DIAGNOSIS**

**DIFFERENTIAL DIAGNOSIS**
Other causes of mastitis and cardiac disease

**CBC/BIOCHEMISTRY/URINALYSIS**
- No characteristic changes on CBC
- Elevation of liver enzymes such as AST and LDH
- Elevated CK

**OTHER DIAGNOSTIC PROCEDURES**
Finding of plant material within gastric contents on gross pathology

**TREATMENT**

**THERAPEUTIC APPROACH**
- Remove from source
- Treatment of mastitis
- Supportive care

**MEDICATIONS**
N/A

**CONTRAINDICATIONS**
N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**
- Recovery possible
- Death

**PREVENTION**
Avoid feeding avocado plant material or grazing near avocado trees.

**MISCELLANEOUS**

**ASSOCIATED CONDITIONS**
N/A

**PRODUCTION MANAGEMENT**
Restrict grazing of livestock from avocado groves

**ABBREVIATIONS**
- AST = aspartate aminotransferase
- CK = creatine kinase
- LDH = lactate dehydrogenase

**SEE ALSO**
- Mastitis: No Growth
- Toxicology: Herd Outbreaks

**Suggested Reading**
Burrows GE, Tyrl RJ. Lauraceae, Chapter 45.

**Author** Jennifer S. Taintor
**Consulting Editor** Christopher C.L. Chase

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