Abomasal Emptying Defect in Sheep

**Abomasal Emptying Defect (AED)**

**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**
N/A

**SYSTEMS AFFECTED**
Digestive

**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 esophagus.

**HISTORICAL FINDINGS**
- Condition occurs sporadically, typically affecting a single individual.
- Owners may note that the animal appears "bloated" despite inappetence.
- Affected animals may be in constant motion, reflecting almost constant rumen activity.
- Sheep with AED are in varying stages of malnutrition, dental problems, parasitism, and/or neurons of the enteric plexus.
- The syndrome is typically characterized by chronic, progressive weight loss.
- Many affected animals 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 esophagus.

**CAUSES AND RISK FACTORS**
Unknown

**DIAGNOSIS**

**DIFFERENTIAL DIAGNOSES**
- Dietary deficiencies
- Neurotoxicosis
- Malabsorption
- Ganglioneuromas
- Degenerative changes

**OTHER LABORATORY TESTS**
- Elevated rumen chloride concentration is useful in supporting a diagnosis of AED.
- Normal rumen chloride in sheep is ≤15 mEq/L. Affected sheep will have at least a two-fold increase.
- Rumen fluid samples are easily obtained by percutaneous aspiration of the rumen from a site in the ventral abdominal wall, the normal abomasum will not extend beyond the last rib.

**IMAGING**
Abdominal radiography 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 usually appear 2 to 4 times normal size.

**THERAPEUTIC APPROACH**
- The prognosis for recovery with intensive treatment is variable and dependent upon the duration of abomasal dysfunction and distention. Medical therapy using cathartics and laxatives, and surgical therapy (abomasotomy) have had limited success.
- In animals that are good surgical candidates, abomasotomy followed by metoclopramide and supportive fluid therapy has provided some success.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**
Abdominal surgery 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.

**DRUGS OF CHOICE**
Metoclopramide (0.1 mg/kg, SQ) as an adjunct to abomasotomy has been reported to improve abomasal motility. This medication should not be used if GI obstruction is suspected.
Abomasal Emptying Defect in Sheep (Continued)

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.

ZOONOTIC 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

• Acquired dysautonomia
• Functional pyloric stenosis
• Ovine abomasal enlargement

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
Acknowledgment The author and book editors acknowledge the prior contribution of Michelle Kopcha.
OVERVIEW

Abomasal impaction occurs when there is obstruction to the passage of fluid and ingesta from the abomasum through the pylorus by feed, sand, gravel or other foreign bodies, or as a result of neurologic dysfunction from various conditions.

- Pyloric obstruction from improperly placed perforating fixation of left displaced abomasum (“roll and toggle”) can also result in abomasal impaction in cattle.
- Clinical signs can be acute or chronic and are characterized by anorexia, decreased or scant feces, abomasal distension, weakness, dehydredration, and signs of abdominal pain.
- Abomasal impaction typically occurs in cattle and occasionally in sheep. It is usually sporadic, but morbidity can be associated with feeding of low-quality forages.
- This disorder has a high mortality rate.
- Abomasal empyema defect (AED) is a disorder that primarily affects Suffolk sheep and is characterized by distension and impaction of the abomasum.

INCIDENCE/PREVALENCE

Low mortality.

GEOPHAGIC DISTRIBUTION

Worldwide. Occurs more commonly in regions where low quality roughage or low energy diets are fed.

SYSTEMS AFFECTED

Digestive

PATHOPHYSIOLOGY

- Physical obstruction of outflow from the abomasum to the gastrointestinal tract can occur due to impaction.
- Abomasal distension can be due to inadequate outflow from the abomasum.
- Abomasal impaction results in distension and may lead to other predisposing causes.
- Pyloric obstruction from improperly placed perforating fixation of left displaced abomasum (“roll and toggle”) can also result in abomasal impaction in cattle.
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HISTORICAL FINDINGS

- Abomasal impaction often affects cattle on poor-quality pasture or that are fed chapped, low-quality forages with low dietary energy, especially in cold weather. Beef cattle are more prone due to management characteristics.
- The disorder may also arise in cattle eating from sand or gravel surfaces, or if excessive gravel from the feed storage area contaminates the feed.
- Animals may also develop the condition as a result of peck.

SIGNALMENT

- This disorder typically affects cattle and sometimes sheep.
- Suffolk sheep may be predisposed compared to other ovine breeds due to the higher prevalence of AED in this breed. Abomasal impaction affects juvenile to adult animals. AED affects sheep >2 years old.
- Abomasal impaction may be more prevalent in pregnant females.

PHYSICAL EXAMINATION FINDINGS

- Anorexia, depression, and decreased rumen motility are typical.
- Distension of the abomasum may be identified by visualization, palpation, and ballottement of the lower right flank.
- Affected animals eventually display weight loss, reduced feed production, and dehydration.

GENETICS

A hereditary pattern has not been demonstrated for abomasal impaction or for AED.

CAUSES AND RISK FACTORS

- From conditions that damage the vagus nerve.
- Late pregnancy may predispose.
- Suffolk sheep with AED are predisposed compared to other ovine breeds due to the higher prevalence of AED in this breed. Abomasal impaction affects juvenile to adult animals. AED affects sheep >2 years old.
- Abomasal impaction may be more prevalent in pregnant females.

DIFFERENTIAL DIAGNOSES

- Include other disorders that may cause signs of inappetance, 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.
- With AED do not typically demonstrate the hypochloremic, hypokalemic metabolic alkalosis commonly found in cattle with outflow obstruction disorders.

IMAGING

- Ultrasonography may be useful to determine distension of the abomasum and to assist in the identification of potential ingesta causes such as traumatic reticuloperitonitis and lymphoma.
- Radiography may be useful to detect traumatic reticuloperitonitis or the presence of excessive sand or gravel within the gastrointestinal tract.

OTHER DIAGNOSTIC PROCEDURES

- Measurement of rumen chloride using fluid samples obtained by orogastric tube or rumenocentesis.
- Laparotomy.
- Abdominocentesis can identify elevated nucleated cell counts, elevated total protein concentration, and/or abnormal cellular morphology in animals with underlying causative disorders that are inflammatory or neoplastic in nature.

PATHOLOGIC FINDINGS

- Abdominocentesis can identify elevated nucleated cell counts, elevated total protein concentration, and/or abnormal cellular morphology in animals with underlying causative disorders that are inflammatory or neoplastic in nature.

TREATMENT

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.
- Correction 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 paramedian.

MEDICATIONS

DRUGS OF CHOICE

- Cathartics and laxative options include mineral oil (0.5 g/kg/day), magnesium sulfate (2.5 g/kg/day), mineral oil (6 mL/kg/day), and magnesium hydroxide (1 g/kg/day).
**Abomasal Impaction (Continued)**

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

**Contraindications**
- 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, inappetence, 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.

**Zoonotic 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

**Suggested Reading**

**Author**
- Judd P. Reynolds

**Consulting Editor**
- Erica C. McKenzie
Abomasal Ulceration

OVERVIEW
Abomasal ulceration represents damage to the abomasal mucosa allowing 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 distension of the abomasum and reflux of abomasal contents into the rumen. Melena is typically observed. Type III ulcers completely perforate the lining 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 straw bedding to a change of pulp, may cause ulceration in the abomasal mucosa. The disorder affects cattle, and rarely sheep and goats. There are no breed or gender predispositions; however, dairy cattle may have a higher prevalence. It occurs in calves and adults.

PHYSICAL EXAMINATION FINDINGS
- Melena or occult blood is observed in feces.
- Possible distension of the abomasum detected 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 (bruxism).
- Peracute death common in adult cattle but not calves.

CAUSES AND RISK FACTORS
This disorder has been associated with physical irritation from straw ingestion, reduction in milk feeding in milk-fed calves, high concentrate feeding in feedlot cattle, straw ingestion in veal calves, oxidative stress associated with high grain diets in feedlot cattle, physical irritation from straw ingestion in veal calves and high grain diets in feedlot cattle. Risk factors might include sudden transition from milk diet to dry feed in calves, straw feeding in milk-fed calves, high concentrate diets in feedlot cattle, recent parturition, and peak milk production.

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

CBC/BIOCHEMISTRY/URINALYSIS
- Acute hemorrhagic anemia in cases of severe gastric hemorrhage, elevated fibrinogen, altered total protein concentrations.
- 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
- Abdominoscopy may identify peritonitis, with increased leukocyte count, phagocytosed or free bacteria, and possibly feed particles in some cases.
- Testing for occult blood in feces may detect blood in the feces before melena is visible.

IMAGING
Ultrasound may show free fluid and fibrosis in the abdomen.

TREATMENT
- Treatment options in calves include oral administration of antacids (25–50 ml q12h) or ranitidine (50 mg/kg q8h) and omeprazole (4 mg/kg q24h).
- Blood transfusion may be beneficial if bleeding ceases or can be controlled, and is indicated if hematocrit declines to <24%
- 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.

PRECAUTIONS
- Avoid NSAIDs and corticosteroid drugs, particularly in susceptible populations.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.

PATHOLOGIC FINDINGS
- Ulcers are most commonly found along the greater curvature and usually in the fundic area. Ulcers can be a few millimeters to several centimeters in size. They are often filled with debris or clotted blood. Perforating ulcers are usually adhered to the omentum.
- Diffuse fibrinous peritonitis may be evident with leakage of blood in the distal GI tract.

Ruminant, Second Edition

BASICS

OVERVIEW
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- Diffuse fibrinous peritonitis may be evident with leakage of blood in the distal GI tract.

Ruminant, Second Edition
Abomasal Ulceration (Continued)

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.

MISCELLANEOUS

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

Overview
Pregnancy loss between 42 days and term, caused by bacterial infection

Incidence/Prevalence
- Abortion rates depend on the pathogen and immunologic status of the herd.
- Abortion rates range from 10% (serovar Hardy of L. pneumophila, serovar) to 50–70% (serovar Pomona of L. pneumophila, bovine, epizootic bovine abortion).

Geographic Distribution
- Worldwide
- Epizootic bovine abortion: California, Nevada, and Oregon

Systems Affected
- Reproductive
- Other systems depending on cause

Pathophysiology
- Infection occurs spontaneously, via inhalation or across conjunctival mucosa.
- Ticks act as vectors for epizootic bovine abortion, Anaplasma spp., and Coxiella burnetii.
- Conceptus infection via hematogenous spread, ascending infection through the cervix, or descending infection from the abdomen through the oviducts.
- Bacteria may cause placemort and fetal septicaemia via the umbilical veins or by ingestion of amniotic fluid.
- Fetal death occurs secondary to placental insufficiency, fetal septicaemia, lysis of the cotyledons, dysentery, pneumonia, polyarthritis, pyrexia, abortion during the second half of gestation.
- T. pyogenes (formerly Arcanobacterium pyogenes): Organ abscission with variable signs, purulent to hemorrhagic vaginal discharges.
- Anaplasma spp. (formerly A. marginale): Pale mucus membranes, icterus, fever, weakness, abortion during the acute phase of maternal disease.
- Ureaplasma diversum: Embryonic death, last trimester abortion, stillbirth, weak calves.

Incidence
- Abortion rates depend on the pathogen and immunologic status of the herd.
- Abortion: Bacterial
- Opportunistic bacteria
- Modifiers
- Inappropriate biosecurity measurements and vaccination schedules
- Seasonal presence of ticks and vectors
- Exposure to wildlife and rodents

Diagnosis
- Some bacterial culture from aborted tissues (lung, pleura, liver, and uterine contents, placenta, and dam’s milk).
- Dam and fetal serology
- Immunohistochemistry and/or immunofluorescence on fetal tissues
- PCR on aborted tissues (leptospirosis, brucellosis, campylobacteriosis, C. burnetii, C. abortus).

Other Laboratory Tests
- Direct identification on Giemsa-stained blood smears (Anaplasma spp.).

Imaging
- N/A

Other Diagnostic Procedures
- Abortion in the last trimester, weak or premature calves, RFM, mastitis, infertility.
- Exposure to wildlife and rodents

Pathologic Findings
- Infants may develop secondary to retained fetal membranes (RFM) or a retained macerated fetus and metritis.
- Campylobacter fetus serovar: Infection, pregnancy loss between 15 and 80 days’ gestation, or abortion at 4 to 6 months.
- Listeria spp.: Last trimester abortion, stillbirth, weak calves, and infertility.
- Severe acute disease with hemolytic anemia, hemoglobinuria, and mastitis with serovar Pomona.
- Brucella abortus: Abortion after 5 months’ gestation, weak or premature calves, RFM, metritis, infertility, carpal hygromas, regional lymphadenitis.
- Listeria monocytogenes and L. ivanovii: Abortion in the last trimester, meningosepticemia, metritis, weight loss, maternal and neonatal septicaemia.
- Histophilus somnus: Pneumonia, arthritis, mesovarianitis, meningosepticemia, sporadic abortions in the second half of gestation.
- Salmonella enterica serovar Dublin: Enteritis, dysentery, pneumonia, polyarthritis, pyrexia, abortion during the second half of gestation.
- Trapaella puyensis (formerly Aracnobacterium pyogenes): Organ abscission with variable signs, purulent to hemorrhagic vaginal discharges.
- Anaplasma marginale: Pale mucus membranes, icterus, fever, weakness, abortion during the acute phase of maternal disease.
- A. phagocytophilum: Fever, cough, nasal discharge, abortion during the acute phase of maternal disease.

A. phagocytophilum: Fever, cough, nasal discharge, abortion during the acute phase of maternal disease.
- Epizootic bovine abortion: Last trimester abortion, premature births.
- Chlamyphila abortus: Abortions at 6 to 8 months’ gestation, stillbirth, weak calves, RFM, metritis, infertility.

Genetics
- N/A

Causes and Risk Factors
- Contagious bacteria
- B. abortus, C. fetus (subsp. wadsworthii and fetus), C. jejuni, Listeria spp., L. monocytogenes, H. somnus, 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. koenigii, M. canadense, M. leachii, Ureaplasma diversum
- Opportunistic bacteria
- Modifiers
- Inappropriate biosecurity measurements and vaccination schedules
- Nutritional, social or environmental stress
- Seasonal presence of risks and vectors
- Exposure to wildlife and rodents
**ABORTION: BACTERIAL**

**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**

- Dystocia
- RFM
- Metritis
- Infection
- Infertility

**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 animals.

**PREVENTION**

- Treatment of systemic disease, RFM, metritis or hypocalcemia as needed.
- Vaccination can be curative (Campylobacter spp.).
- Appropriate immunization program, nutrition, and environmental management.
- Test and cull positive animals.
- Use artificial insemination.
- Appropriate immunization program, nutrition, and environmental management.
- Monitor herd for further abortions, stillbirths, or birth of weak calves.
- Change silage source (listeriosis).
- Monitor cow for RFM and metritis.
- Test and quarantine new animals.
- Proper disposal of aborted tissues.
- Vaccination Programs: Dairy Cattle
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**SURGICAL CONSIDERATIONS AND TECHNIQUES**

**MEDICATIONS**

<table>
<thead>
<tr>
<th>DRUGS OF CHOICE</th>
<th>CONTRAINDICATIONS</th>
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<tbody>
<tr>
<td><em>H. somnus</em> β-lactams, florfenicol, tetracycline, and sulfonamides</td>
<td>N/A</td>
</tr>
<tr>
<td><em>Listeria</em> spp.: tetracycline</td>
<td>N/A</td>
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<tr>
<td><em>U. urealyticum</em> and <em>Mycoplasma</em> spp.: tetracycline, tylosin</td>
<td>N/A</td>
</tr>
<tr>
<td><em>C. abortus</em>: tetracycline</td>
<td>N/A</td>
</tr>
<tr>
<td>Epizootic bovine abortion: chlortetracycline</td>
<td>N/A</td>
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**ASSOCIATED CONDITIONS**

- Milk and meat withdrawal times should be followed.

**POSSIBLE INTERACTIONS**

- LOW

**MISCELLANEOUS**

- See "Prevention."

**ABBREVIATIONS**

- CL = corpus luteum
- RFM = retained fetal membranes

**SEE ALSO**

- Abortion: Bovine
- Abortion: Viral, Fungal, and Nutritional
- Brucellosis
- Campylobacter
- Chlamydiosis
- Campylobacter
- Listeriosis
- Q Fever (Coxiella)
- Vaccination Programs: Beef Cattle
- Vaccination Programs: Dairy Cattle

**Suggested Reading**

- Author Maria Soledad Ferrer

**Acknowledgment**

The author and book editors acknowledge the prior contribution of Walter Johnson and Alex Estrada.
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 <5% 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 pallidum, Fusobacterium spp., Listeria spp., E. coli, and L. interrogans.

SYSTEMS AFFECTED
• Reproductive • Other systems depending on outcome

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 infections 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 infectious agent. • The time between fetal death and expulsion may be characteristic for a pathogen. • Noninfectious causes of abortion include nutritional imbalance, cesarean birth administration, malnutrition, stress, environmental toxins, teratogenic compounds, hormone imbalances, and genetic abnormalities. • Abortion may result due to fetal death following: • Infection by microorganisms through hemogenous 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 placentitis leading to fetal hypoxia and death. • Maternal compromise (matritis, 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/autopsy 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.

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. • Deformities. • Visual abnormalities.

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). Infection of blood or placenta may be more likely to affect several animals within the herd simultaneously. • Risk factors include lack of biosecurity measures, presence of vectors or toxins, overcrowding, etc.

GENETICS
N/A

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). • Bovine viral diarrhea virus (BVDV).

• Bacteriology/Virology
• Samples should be taken from the fetus (stomach contents, fetal fluids both thoracic and abdominal, kidney, liver, lung, spleen, and thymus), from the dam (vaginal discharge, urine, milk), 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 should be submitted fixed in formalin and fresh chilled to a diagnostic laboratory for further evaluation. Collection of coagulated fluid (freeze) for nitrate/nitrites levels. • Placental evaluation: External examination of the chorion (including the cotyledons) and amnion. External examination for signs of placentitis (thickening, degeneration, 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 (cotyledons and intercotyledary areas), along with any subjective abnormal areas, should be submitted in formalin and fresh chilled for further evaluation.

Abortion: Bovine

Differential diagnoses
• Akabane virus (Akabane virus). • Bluetongue virus (BTV).
Abortion: Bovine (Continued)

**MEDICATIONS**

**DRUGS OF CHOICE**

May be indicated in some cases

**CONTRAINDICATIONS**

N/A

**PRECAUTIONS**

N/A

**POSSIBLE INTERACTIONS**

N/A

**FOLLOW-UP**

**EXPECTED COURSE AND PROGNOSIS**

Dependent on the cause of abortion

**POSSIBLE COMPLICATIONS**

Dystocia, retained placenta, metritis, mastitis, infertility

**CLIENT EDUCATION**

• Establish good preventative programs: biosecurity measures, immunization programs, adequate nutrition, parasite control.
• Producers should have an Immunization program
• Adequate nutrition, including balanced trace minerals, for the herd is important for elimination of some of the causes of abortion.
• Isolation of affected cow(s) from remaining group.
• Adequate nutrition, including balanced trace minerals, for the herd is important for elimination of some of the causes of abortion.

**PATIENT CARE**

• Responsible use of medications.
• Adequate nutrition, including balanced trace minerals, for the herd is important for elimination of some of the causes of abortion.

**PREVENTION**

• General prevention program for abortion (guidelines for biosecurity):
• Quarantine new animals (4 to 6 weeks)
• Immunization program
• Keep feed, pasture, and water sources free from contamination
• Control rodents, birds, and ferid animal populations.

**SUGGESTED READING**


Author Alex Campbell
Consulting Editor Ahmed Tibary

**ZOO NOTIC POTENTIAL**

• Brucellosis (Brucella abortus)
• Campylobacteriosis (C. jejuni)
• Chlamydial organisms

**PREGNANCY**

N/A

**BIOSECURITY**

See "Prevention"

**PRODUCTION MANAGEMENT**

N/A

**SYNONYMS**

N/A

**ABBREVIATIONS**

• CL = corpus luteum
• PGF2α = prostaglandin F2α

**SEE ALSO**

• Abortion: Bovine
• Abortion: Viral, Fungal, and Nutritional

**TREATMENT**

**THERAPEUTIC APPROACH**

Depends on systemic involvement and other complications

**SURGICAL CONSIDERATIONS**

N/A

**MISCELLANEOUS**

**ASSOCIATED CONDITIONS**

N/A

**AGE-RELATED FACTORS**

N/A

**EXPECTED COURSE AND PROGNOSIS**

Dependent on the cause of abortion

**POSSIBLE COMPLICATIONS**

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• Quarantine new animals (4 to 6 weeks)
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• Keep feed, pasture, and water sources free from contamination
• Control rodents, birds, and ferid animal populations.

**SUGGESTED READING**


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%.
- Loss of up to 60% may be experienced in some leptospirosis outbreaks (e.g., leptospira, brucellosis).
- 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
Camelids 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 F₂α
- Iatrogenic or infectious process
- Endotoxemia
- Stress such as heat stress or transport
- Debilitating diseases
- Abortion can be caused by compromised fetal viability or placental integrity:
  - Placentitis
  - Placental insufficiency (endometrial fibrosis, uterine capacity in maiden females, twinning)
  - Direct insult to the fetus (mechanical or infectious)
  - Fetal malformation/abnormal pregnancy
  - Hormonal insufficiency or imbalance

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

PHYSICAL EXAMINATION FINDINGS
Females of breeding age

INFEKTIVE CAUSES OF ABORTION
- Viral causes:
  - Bovine viral diarrhea virus (most common serotype affecting alpacas and llamas is noncytopathic BVDV-1b)
  - Equine herpes virus-1 (potential)
- Bacterial causes:
  - Brucellosis (B. ovis/ B. abortus)
  - Listeriosis
  - Leptospirosis
  - Q fever (Coxiella burnetii)
- Protozoal causes of abortion:
  - Toxoplasmosis (Toxoplasma gondii, cats)

NONINFEKTIVE CAUSES OF ABORTION
- Iatrogenic causes of abortion:
  - Administration of PGF₂α
  - Administration of corticosteroids (even topical) in the second half of pregnancy
- Nutritional causes of abortion:
  - Nutritional deficiencies or administration of corticosteroids
- Toxic plants (limited information available)
- Gestational complications
- Fetal/placental causes of abortion:
  - Uterine/cervical insufficiency
- Congenital anomalies
- Placental insufficiency

DIFFERENTIAL DIAGNOSES
Evaluation of the female should include:
- Teat bud ultrasonography
- Vaginal speculum examination
- Urine cytology, 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.
- Pathology
  - 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.
  - Necropsy/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.
- Placental evaluation:
  - External examination of the chorionic surface for lack of villi (placental insufficiency) or signs of placitis (thickening, degeneration, erudate).
  - 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.

CB/CBC BIOCHEMISTRY/URINALYSIS
May be indicated depending on disease condition

OTHER LABORATORY TESTS
See "Diagnosis"

IMAGING
N/A

OTHER DIAGNOSTIC PROCEDURES
See "Diagnosis"

PATHOLOGIC FINDINGS
• Studies on pathological findings in camelid abortion are scarce.
• Placentitis is a common feature in bacterial and fungal abortions.
• Placental insufficiency is often suspected if large avillous areas are seen on the placenta.
• Fetal abnormalities are common.

TREATMENT

THERAPEUTIC APPROACH
• Dependent on the cause of abortion
• Abortion due to hypoluteoidism
• Requires progesterone supplementation (injections of progesterone or hydroxyprogesterone caproate, norgestomet implant). Alenrogest is not active orally in camelids.
• Hydroxyprogesterone caproate 250 mg IM, every 3 weeks with treatment discontinued at 300 days to allow normal parturition.
• Fetal viability should be monitored regularly if progesterone supplementation is implemented.
• Placental insufficiency
• Early diagnosis and termination of twins.
• Early diagnosis of uterine fibrosis (uterine biopsy) and sexual rest.

SURGICAL CONSIDERATIONS AND TECHNIQUES
N/A

MEDICATIONS

DRUGS OF CHOICE
N/A

CONTRAINDICATIONS
Appropriate milk and meat withdrawal times must be followed.

PRECAUTIONS
N/A

POSSIBLE INTERACTIONS
N/A

FOLLOW-UP

EXPECTED COURSE AND PROGNOSIS
See specific disease/condition

POSSIBLE COMPLICATIONS
Dystocia, metritis, endometritis, retained placenta, infertility

CLIENT EDUCATION
• Pregnancy should be monitored in the first 60–90 days of gestation.
• Producers should have a plan if an abortion occurs (isolation of affected females, collection of aborted materials for submission to veterinarian, examination of female and aborted). 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.
• Adequate nutrition, including balanced trace minerals, for the herd is important for elimination of 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.
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PATIENT CARE
• Depends on the cause of abortion and complications.
• Supportive care is important in debilitated animals.

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 in high-risk situations).

MEDICATIONS

DRUGS OF CHOICE
N/A

CONTRAINDICATIONS
Infertility, dystocia, poor systemic health

ASSOCIATED CONDITIONS
Fetal abnormalities

MISCELLANEOUS

ASSOCIATED CONDITIONS
Fetal abnormalities

AGE-RELATED FACTORS
N/A

ZOOLOGIC POTENTIAL
Possible for brucellosis (B. melitensis, B. abortus), Chlamyphila abortus, leptospirosis, Q fever

PREGNANCY
N/A

PRODUCTION MANAGEMENT
N/A

SYNONYMS
N/A

ABBREVIATION
• CL = corpus luteum
• PGF2α = prostaglandin F2α

SEE ALSO
• Abortion: Bacterial
• Abortion: Viral, Fungal, and Nutritional
• Camel Diseases
• Congenital Defects: Camelids
• Pregnancy Toxemia: Camelids

Suggested Reading

Authors Alex Campbell Consulting Editor Ahmed Tibary Acknowledgment The author and book editors acknowledge the prior contribution of Ahmed Tibary.

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SEE ALSO
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• Camel Diseases
• Congenital Defects: Camelids
• Pregnancy Toxemia: Camelids

Suggested Reading

Authors Alex Campbell Consulting Editor Ahmed Tibary Acknowledgment The author and book editors acknowledge the prior contribution of Ahmed Tibary.
transrectal palpation (in wapiti) or transrectal fetal/embryonic loss can be confirmed by season, a female may come back into estrus. Pregnancy had been confirmed early in the season, a female may exhibit the following clinical signs:

- Premature udder development and dripping
- Presence of expelled fetus and/or placenta
- Bloody or purulent vaginal discharge
- Iodine deficiency

Metabolic Causes

- Inadequate nutrition: Pregnant white-tailed deer females experience a 16% increase in fasting metabolic rates during gestation, 92% of which is in the 3rd trimester in early spring. Females with adequate body condition entering the winter months are more likely to have adequate fat reserves to fulfill gestational requirements in the event of prolonged winter. Females with inadequate fat reserves or that do not receive adequate nutrition in the spring may abort or give birth to nonviable or underweight calves. Iodine deficiency. Abortion and stillbirth have been reported in cervid species due to iodine deficiency. The deficiency may be caused by insufficient dietary intake, or be 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: Biavas 1 and 4 have been recovered from wild elk in the Yellowstone area of the US. Natural infections have not been reported in axis deer, white-tailed deer, or mule deer, but experimental infections have been established in all three, suggesting potential for interspecies transmission. Brucellosis. Studies in red deer showed reproductive effects, mostly reduced weaning rates, but no reports of abortions. Abortions following experimental inoculation with B. abortus have been demonstrated in white-tailed deer, demonstrating an abortigenic potential in cervid species. Listeriosis: The septicemic form has been reported to cause placentitis 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 Eld’s deer and perinatal death in fallow deer and axis deer with a suspected vertical transmission.

Viral Causes

- Bluetongue (BTV; orbivirus): Infection of cervid species generally leads to hemorrhagic disease and death. Under experimental inoculation, early embryonic absorption and fetal death were both reported in white-tailed deer. EHDV; orbivirus: Usually resulting in widespread hemorrhages, 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. Bovine viral diarrhea virus (BVDV; pestivirus) has been isolated from wild cervids in North America. Cervid species experimentally inoculated with cattle-derived BVDV experienced mild or no clinical disease. Experimental inoculation with a deer-derived BVDV strain in white-tailed deer resulted in fetal abortion and resorption and establishment of persistently infected (PI) carrier animals, similar to those effects observed in cattle, indicating a potential for natural infection. Cervid herpesvirus 2 (CvHV-2; Varicellovirus): Endemic in Norway reindeer populations. Reports of vertical transmission and neonatal death in experimentally infected reindeer suggest an abortogenic potential, though this has yet to be reported in naturally occurring abortions.
**Abortion: Farmed Cervidae**

(Continued)

**Other Causes**
- Other causes of abortion or stillbirth include toxicoses, traumatic injuries, congenital abnormalities, and administration of some drugs. Lactocord causes abortions in sheep and cattle and may be a problem for cervidae as well. Congenital abnormalities, fetal oversize, 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
- Pyometra
- Menitis
- Uterine trauma or hemorrhage
- Uterine or vaginal neoplasia
- Mixed due date
- Infertility, either male or female (if pregnancy was not confirmed)
- Incorrect due date
- Signs of impending parturition before due date
- Isolation: may indicate neologic disease
- Abdominal straining: colic due to bleed (foalhy vs. feta gas) or other GI disease.

**CBC/Biochemistry/Urinalysis**

Little data is available on routine analyses but may be extrapolated from domesticated ruminants taking into account cause of abortion.

**Other Laboratory Tests**

**Pregnancy Diagnosis and Monitoring**


**Imaging**

- Transvaginal ultrasonography: Used for early pregnancy detection (30–60 days) and fetal counting if performed within the first 2 trimesters.
- Transabdominal 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**

Neocropy and sample collection of aborted feta and placenta should occur as soon as possible to minimize secondary bacterial overgrowth. It may be difficult to obtain the placenta as the fetus usually ingests it. In herd outbreaks, it may be worthwhile to sacrifice a female for postmortem diagnosis if fetal tissues are inconclusive. Paired serology that shows rising antibody titers in the female may also be beneficial for antemortem diagnosis in some cases.

**Bacterial Abortions**

- Brucellosis: Four serological tests available – card test, standard plate agglutination test (SPT), complement-fixation (CF) test, and serum test. Positive serology requires that a confirmatory test be performed. This includes culture and isolation of Brucella from tissues, secrections, or excretions. Test results must be reported to state and federal animal officials.
- Leptospirosis: Paired serology.
- Microscopic agglutination test (MAT) and enzyme-linked immunosorbent assays (ELISA): MAT will evaluate response to a selection of serovars.
- Immunofluorescence (IHC) staining or polymerase chain reaction (PCR) on aborted tissue.
- Listeriosis: In captive species, cerebrospinal fluid analysis can show a markedly elevated protein concentration and neutrophilic pleocytosis. These results combined with neurologic manifestations are almost pathognomonic for listeriosis, though no pre-mortem confirmatory test is currently available.
- Anti-Listeria IHC from the brainstem in deceased animals is quick and most effective for verifying the diagnosis.

**Parasitic Abortions**

- Toxoplasmosis or Neospora: Serology Indirect or direct hemagglutination, indirect immunofluorescent antibody test, ELISA.
- Real-time PCR or IHC on aborted tissue.

**Viral Abortions**

- BTV or EHDV: Serology (competitive ELISA, agar gel immunodiffusion, microtit seroneutralization [MVN]); IHC, PCR, virus isolation of aborted tissue.
- BVDV: Paired serology (MVN, ELISA); virus isolation from blood or nasal secretions; IHC of aborted tissue.
- CVH-2: Serology (ELISA); PCR from tissues, nasal swabs, trigeminal ganglia samples.

**Pathologic Findings**

Depends upon etiology.

**Bacterial Abortions**

- Brucellosis: Necrotizing placentitis characterized by a thickened placenta covered with a purulent exudate.
- Leptospirosis: Gross lesions in aborted white-tailed deer fetuses (following experimental inoculation with L. pomona) included swollen, hemorrhagic, polyhyaline kidneys, liver, and lymph nodes.
- Listeriosis: Evidence of fibrinopurulent to necrotizing placentitis on histopathology; fetuses may have either no gross lesions or suppurative pneumonia and meningitis.

**Parasitic Causes**

- Toxoplasmosis: Necrotizing placentitis and multifocal nonsuppurative encephalitis of the fetus with presence of tissue cysts histologically in sections of brain and thymusites in placenta and myocardium that stain positive with Z. girdii 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 dystrophic pathologies have been described in aborted fetuses, but severe autolysis has been noted. Affected reindeer cows have demonstrated mild to moderate intermittent venous pneumonia.

**Fungal Causes**

Granulomas (gross), fungal hyphae (histopathology) on affected organs.

**Treatment**

**Therapeutic Approach**

N/A

**Surgical Considerations and Techniques**

N/A

**Medications**

**Drugs of Choice**

- Depending upon etiology
- Broad-spectrum antibiotics: Indicated for specific bacterial diseases; long-acting antibiotics require less frequent dosing and will help to minimize stress of handling.
- Anti-inflammatory: Flunixin meglumine (1.1–2.2 mg/kg IV) or meloxicam (0.5 mg/kg PO) can be administered once daily.

**Contraindications**

N/A

**Precautions**

N/A

**Possible Interactions**

N/A

**Follow-up**

**Expected Course and Prognosis**

- Depending upon underlying cause
- BTV and EHDV are most likely to cause rapid, acute death.
- CVH-2 may become latent and reemerge during periods of stress.
- BVDV may lead to persistently infected animals that can shed the virus throughout their lifetime.

**Possible Complications**

- Decreased fertility, increased morbidity in females
- Dysuria, 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 ( Fluids)  
- Anti-inflammatories 2 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 histoplasmosis or mycosis 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:  
  - Interstate 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 but not from certain management procedures.

**Animals for interstate movement**

- A negative 30-day pre-slaughter test is required in addition to an interstate movement test.

**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.

**SYNONYMS**

- N/A

**ABBREVIATIONS**

- BTV = bluetongue virus  
  - BPVDV = bovine viral diarrhea virus  
  - EHDV = epizootic hemorrhagic disease virus  
  - ELISA = enzyme-linked immunosorbent assay  
  - IHC = immunohistochemistry  
  - MAT = microscopic agglutination test  
  - PDG = pregnant-ovine-Sheep-plasma-glucoamylase  
  - PI = persistently infected  
  - PSPB = pregnancy-specific protein B  
  - SPT = standard plate agglutination test

**SEE ALSO**

- Abortion: Bovine Viral Diarrhea Virus
- Cervidae: Biosecurity
- Cervidae: Breeding Soundness Examination
- Cervidae: Reproduction
- Cervidae: Vaccination Programs

**Suggested Reading**

Basso W, Mori G, Quirina MA, et al.  
**Abortion: Small Ruminant**

**Clinical Signs**
- Several infectious abortions are subclinical in the dam (Cache Valley, Border disease, caprine herpesvirus, Schmallenberg, Q fever).
- Bluetongue: Febrile, swollen tongue, ear or face, lameness, ulcerative lesions on month.
- Campylobacteriosis: Abortions may show diarrhea.
- Chlamydia: Paratuberculosis, keratoconjunctivitis, epididymitis, and polyarthritis. Anorexia, fever, bloody vaginal discharge 2 to 3 days before abortion.
- Brucellosis (B. melitensis) in goats: weak kids and mastitis. Aborting goats may experience fever, depression, weight loss, mastitis, and lameness. *B. ovis* in sheep: Rarely a cause of abortion but is responsible for poor reproductive performance and in the ram contagious epididymitis.
- Leptospirosis: Anorexia, fever, marked jaundice, hemoglobinuria, anemia, neurological signs, abortion, occasionally may be fatal.
- Salmonellosis: Abortion, retained placenta, mastitis, and various systemic signs (fever, depression, diarrhea). Mostly in overcrowded flocks. Toxoplasmosis: Generally no clinical signs; immunocompromised females may present a neurologic form of the disease.
- Leprosy: Septicemia, fever, decreased appetite, reduced milk production, abortion, and meningoencephalitis. Mycoplasmosis: (goats): Mastitis, arthritis, keratoconjunctivitis, vulvovaginitis, and abortion in the last 3rd of pregnancy.

**CAUSES AND RISK FACTORS**
- *C. abortus,* Gram-negative intracellular organism. *Abortions* and other clinical signs in neonates. *Abortions* females become immune. *Females* infected after 100 days of pregnancy may not abort. Diagnosis: *Placentitis,* placental retention. In the last month of pregnancy, high incidence in newly infected flocks. *Demonstrations* of changes in placental discoloration from cotyledons, vaginal discharge, fetal stomach contents. *Culture* from vaginal discharge, placenta and fetal tissue. PCR: Serology paired samples from dam and fetal serum. *ELISA* or indirect inclusion fluorococ fer antibody tests (IFA). Toxoplasmosis
- Goats more susceptible than sheep. Diagnosis: *C. abortus* are gray-white to yellow and present small 1–3 mm focal area of necrosis and calcification. *Intercostal* areas are generally normal. Macroscopic lesions: 2–3 mm necrotic foci on cotyledons, intercostal interlobular alveolar necrosis are generally normal. Fetus may be mummified or decomposed. Chalk white necrotic brain lesions. *Samples:* placenta, fetal brain, fetal fluids, maternal blood, placenta, fetal fluids, blood, vaginal fluids, tissues (shipped packed in ice). Histopathology: fixed cotyledons, fetal brain. Serology: presence of antibodies in fetal fluids or placental serum is the preferred diagnostic technique and indicates transplacental infection. Q Fever (*Coxiella burnetii*)
- Placental, placental fluids, or thickening of the intercostal area. Abortion and stillbirth. *Placenta:* Vaginal discharges, fetal stomach contents. PCR techniques are available. *Demonstration* of organism by Ziehl-Neelsen staining. Diagnosis: *Samples:* blood, placenta. *Electrofluorescent* tests are available. *PCR* tests may be used to identify organism in frozen section of placenta. Campylobacteriosis
Isolation and Identification

- Samples: Placenta and vaginal discharges, fet fans and fluids, blood, uterine discharges, milk, stomach content.
- Fetal death and resorption may show fever.
- Histopathology: Cerebellum (white matter necrosis and gliosis), spinal cord
- Serology: Flood from dam and hairy shakers.
- Clinical: Small coryledons with focal necrosis, hair shakers.
- Viral isolation: Blood, semen, fetal brain and spleens. Unlike cases of abortion in goats.

**Listeriosis (Listeria monocytogenes)**

- Isolation and Identification
  - Direct diagnosis: Culture from fetal tissues taken aseptically may be preserved at -20°C; placenta and uterine discharges.
  - Indirect diagnosis: Serological tests.

**Mycoplasma abortions (M. mycoides, M. agalactiae)**

- Significant in goats.
- Diagnosis: Culture and serotyping of the isolate from milk, fetal fluids, and placenta.

**Noninfectious Causes of Abortion**

- Genetic: Abnormalities such as anencephaly, hydranencephaly, and mummification.
- Pathological: Congenital abnormalities.
- Detection of antibodies in fetal fluids or precolostral serum.

**OTHER LABORATORY TESTS**

- CBC/Biochemistry/Urinalysis: Depends on etiology and complications.
- Tetracycline, Tylosin: For isolation of Mycoplasma abortions.
- Phenothiazine and analogues: For isolation of L. myxovivax and L. ivanovii.
- Iodine, copper, manganese deficiency.

**TREATMENT**

**THERAPEUTIC APPROACH**

Depending on etiology and complications following abortion.

**SURGICAL CONSIDERATIONS AND TECHNIQUES**

**MEDICATIONS**

**DRUGS OF CHOICE**

- Depends on etiology and complications following abortion.
- Broad-spectrum antibiotics and anti-inflammatory therapy.
- Campylobacter: Penicillin or streptomycin or tetracycline in feed; some strains are resistant.
- Chlamydioides: Tetracycline, Tylosin.
- Leptospirosis: Tetracycline.
- Toxoplasmosis: Decoquinate.
- Mycoplasma: Tetracycline and tylens.

**CONTRAINDICATIONS**

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

**EXPECTED COURSE AND PROGNOSIS**

Dependent upon underlying cause.

**POSSIBLE COMPLICATIONS**

Dystocia, retained placenta, metritis, mastitis, male infertility (brucellosis, chlamydiosis), 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.  
- Zoontic 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**

- Avian disease risk and set up preventive measures.  
- Toxoplasmosis: cat population.  
- Leprosy: spondylosis, humind habitat, proximity to dairy and swine operation.  
- Salmonellosis: source of infection: bird, cattle, wildlife, predisposing conditions: overcrowding, shipping, climatic conditions: overcrowding, shipping, climatic  
- Chlamydia: Infection transmission: placenta, fetal fluids  
- Pigeon/sparrows are reservoirs, ticks or larva  
- Leptospirosis: rodent population, humid environment, crowded conditions.  
- Vaccination + Bluetongue: question able  
- Akabane virus: effective + Cache Valley: effective + Campylobacter: helpful  
- Chlamydia: helpful + Q fever: autogenous vaccines in conjunction with chloramphenicol may help + R. ratti: poor efficacy of killed vaccine + B. melitensis: live attenuated good when permitted + Salmonellosis: autogenous 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, undulant fever, joint pain  
- Leprosy: + Toxoplasmosis (milk, fetal membranes)  
- Listeriosis: aborted fetsuses

**PREGNANCY**

N/A

**BIOSECURITY**

See ‘Prevention’

**PRODUCTION MANAGEMENT**

- Call infective animal  
- Quarantine measures

**SYNONYMS**

N/A

**ABBREVIATIONS**

- ELISA = enzyme linked immunosorbent assay  
- IFA = indirect inclusion fluorescence antibody  
- PCR = polymerase chain reaction  
- BDV = Border disease virus  
- CpvFV:1 = caprine herpesvirus 1  
- RVF = Rift Valley Fever

**SEE ALSO**

- Abortion: Bacterial  
- Abortion: Viral, Fungal, and Nutritional  
- Akabane  
- Anthrax  
- Arbovirus  
- Bluetongue  
- Brucellosis  
- Cache Valley Virus  
- Campylobacter  
- Chlamydia  
- Congenital Defects: Small Ruminants  
- Ehrlichiosis and Anaplasmosis:  
- Leptospirosis  
- Listeriosis  
- Neosporosis  
- Rift Valley Fever  
- Schmallenberg Virus  
- Selenium Toxicity  
- Toxoplasma  
- Toxoplasmosis  
- Vitam A/E  
- Iodine Deficiency and Toxicity  
- Wilson-Bell Disease

**Suggested Reading**


**Author Ahmed Tibary**

**Consulting Editor Ahmed Tibary**

**Client Education Handout available online**
Abortion: Viral, Fungal, And Nutritional

BASICS

OVERVIEW
Pregnancy loss during the fetal stage, between 42 days and term, caused by viral or fungal infection of the fetus or placenta, or nutritional problems.

INCIDENCE/PREVALENCE
- BHV-1: sporadic abortions in vaccinated or previously exposed herds, up to 60% in naïve herds. - BTV: up to 40% in susceptible herds. - Fungal sporadically, <10% of the herd, can vary from 2 to 20% depending on environment and season. - Selenium deficiency: 4–5% of aborted fetuses in a Canadian study.

GEOGRAPHIC DISTRIBUTION
- Potentially worldwide - Seasonal occurrence of bluetongue virus abortions due to vector cycle (late summer and early autumn in temperate areas) - Seasonal occurrence of fungal abortion (winter and spring) - Selenium-deficient areas for selenium toxicity

SYSTEMS AFFECTED
- Reproductive - Other systems depending on etiology

PATHOPHYSIOLOGY

Viral Abortion
- Maternal infection occurs venafermally, orally, via inhalation or across conjunctival mucosa. - Vector transmission occurs with BTV (Culex 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 fresh 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, BHV-1). - Fetal infection with noncytopathic BVDV strains between 1 and 8 months' gestation leads to birth of persistently infected calves, congenital defects, fever, ocular and nasal discharge, oral ulcers, diarrhea, decreased milk production, epithelial erosions at the interdigital spaces, coronary bands, teeth or vulva, hemorrhagic syndrome. - BHV-1: Abortion between 4 and 8 months' gestation, usually 2 weeks to 3 months after maternal clinical disease, respiratory disease, fever, conjunctivitis, nasal lesions, encephalomyelitis, neonatal disease, severe and painful purulent vaginitis. - BTV: Variable depending on host and virus characteristics: infertility, embryonic death, abortion, mummification, 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, teeth or vulva, hemorrhagic syndrome. - Ruminant illness and fever may develop secondary to retained fetal membranes (RFM). - BHV-1: Abortion between 4 and 8 months' gestation, usually 2 weeks to 3 months after maternal clinical disease, respiratory disease, fever, conjunctivitis, nasal lesions, encephalomyelitis, neonatal disease, severe and painful purulent vaginitis. - BTV: Variable depending on host and virus characteristics: infertility, embryonic death, abortion, mummification, 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, teeth or vulva, hemorrhagic syndrome. - BHV-1: Abortion between 4 and 8 months' gestation, usually 2 weeks to 3 months after maternal clinical disease, respiratory disease, fever, conjunctivitis, nasal lesions, encephalomyelitis, neonatal disease, severe and painful purulent vaginitis. - BTV: Variable depending on host and virus characteristics: infertility, embryonic death, abortion, mummification, 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, teeth or vulva, hemorrhagic syndrome.

Fungal Abortion
- Fungi are thought to cause primary maternal respiratory or gastrointestinal disease and spread to placenta/cumously hematogenously. Fetal infection occurs by extension of amniotic fluid infection.

Nutritional Abortion
- Selenium deficiency results from grazing contaminated, or iatrogenic overdose or oral or injectable selenium causes toxicosis. The toxic dose of selenium is uncertain, ranging from 2.2 to >20 mg/kg in the literature.

HISTORICAL FINDINGS
- A herd history of abortions or maternal and neonatal signs described above
- Inappropriate vaccination schedules
- Introduction of new animals to the herd
- Ataxic, blind or small calves in the herd (BVDV)

SIGNALMENT
- Rumination of all breeds - Breeding age females

PHYSICAL EXAMINATION FINDINGS
- Maternal physical examination is usually unremarkable at the time of abortion.
- Maternal illness and fever may develop secondary to retained fetal membranes.
- Bovine respiratory disease: Bovine respiratory disease, fever, conjunctivitis, nasal lesions, encephalomyelitis, neonatal disease, severe and painful purulent vaginitis.
- Fetal infection with noncytopathic BVDV strains between 1 and 8 months' gestation leads to birth of persistently infected calves, congenital defects, fever, ocular and nasal discharge, oral ulcers, diarrhea, decreased milk production, epithelial erosions at the interdigital spaces, coronary bands, teeth or vulva, hemorrhagic syndrome.
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- BTV: Variable depending on host and virus characteristics: infertility, embryonic death, abortion, mummification, 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, teeth or vulva, hemorrhagic syndrome.

Abortion, mummification, 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, teeth or vulva, hemorrhagic syndrome.

Fungal Causes
- Ingestion of infected plants growing in low-selenium soils.
- Ingestion of contaminated feedstuffs (fungal).

Selenium deficiency results from grazing contaminated, or iatrogenic overdose or oral or injectable selenium causes toxicosis. The toxic dose of selenium is uncertain, ranging from 2.2 to >20 mg/kg in the literature.

Neonatal signs (described above)
- Inappropriate vaccination schedules
- Introduction of new animals to the herd
- Ataxic, blind or small calves in the herd (BVDV)

Fungal Causes

Selenium Toxicity or deficiency, toxic plants
- Nutritional Abortion

Risk Factors
- Inappropriate biosecurity measurements and vaccination schedules.
- Nutritional, social, or environmental stress.
- Seasonal presence of vectors.
- Poorly ventilated moist environment, high animal density, animal confinement, and feeding moldy hay and feedstocks (fungal).
- Selenium-deficient soil.

GENETICS

N/A

CAUSES AND RISK FACTORS

Viral Causes
- Bovine herpes virus 1, 4, and 5, bovine viral diarrhea virus, bluetongue virus, bovine parvovirus.
- The most common viral causes of abortion in small ruminants are Akabane, bluetongue, Border disease, Cache Valley virus, caprine parvovirus-1 (goats).

Fungal Causes

Nutritional Causes
- Selenium toxicity or deficiency, toxic plants

Risk Factors
- Inappropriate biosecurity measurements and vaccination schedules.
- Nutritional, social, or environmental stress.
- Seasonal presence of vectors.
- Poorly ventilated moist environment, high animal density, animal confinement, and feeding moldy hay and feedstocks (fungal).
- Selenium-deficient soil.

DIAGNOSIS

DIFFERENTIAL DIAGNOSES
- Additional viral abortions: Bovine enterovirus, pseudocarpavirus, parainfluenza virus 3, lymph skin capripoxvirus, malignant catarrhal fever, bovine leucosis virus, foot and mouth disease virus; emerging or geographically restricted viruses (Kabos virus in Africa, Asia and Australia, Rift Valley fever in sub-Saharan Africa and Madagascar, Akabane virus in Asia, Australia, Middle East and Kenya, Schmallenberg virus in Germany and the Netherlands, Wesselsbron virus in Africa).
- Protozoal abortion: Neospora caninum, Trichomonas foetus.
- Toxic abortion: Nitrate/nitrite poisoning, Ponderosa pine, bromo snakeweed, sumpweed, moldy sweet clover, locoweed, poison hemlock, annual ryegrass infected with Clorox factor toxins, snowdrop, stinkweed, purple worm, wild pea, sweet pea, subterranean clover, skunk cabbage mycotoxins, iatrogenic abortion.
- Yogurt administered with abortogenic or luteolytic drugs.
- Vaginal discharge: Vaginitis, metritis, endometritis, pyometra, hemorrhage.
- Ulcers: Foot and mouth disease, bovine respiratory disease complex.
- Respiratory disease: Bovine respiratory disease complex.
**ABC**

**ABNORMALITIES**

- **Pathological Findings**
  - **BHV-1**: Autolytic fetus, pinpoint white foci associated with abortion.
  - **BVDV**: Persistent fetal or early abortions may develop post-vaccination. Latency may result from vaccination with modified live virus or attenuated vaccines.

**Diagnosis**

- **Pathology**
  - Determination of selenium content in fetal and maternal milk.
  - **Fetal Necropsy** (see finding below)
  - Determination of selenium content in fetal and maternal milk.

**Pathological Findings**

- **BHV-1**: Autolytic fetus, pinpoint white foci associated with abortion.
  - **BVDV**: Persistent fetal or early abortions may develop post-vaccination. Latency may result from vaccination with modified live virus or attenuated vaccines.

**Therapeutic Approach**

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

**Medications**

- **Drug(s) of Choice** N/A

**Contraindications**

- **Use of modified live virus or attenuated vaccine against BVDV in pregnant cattle is associated with congenital malformations.**

**Possible Complications**

- **Dystocia**
  - Fetal membranes may be retained and/ or abnormal calves.

**Client Education**

- **Wear protective gloves and clothes when handling aborted tissue and animals.**
  - Pregnant women, children, elderly and immunosuppressed people should not handle aborted tissue or animals.

**Pathologic Findings**

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**Pathological Findings**

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  - **BVDV**: Persistent fetal or early abortions may develop post-vaccination. Latency may result from vaccination with modified live virus or attenuated vaccines.
BASICS

OVERVIEW
Actinobacillosis is caused by *Actinobacillus ligniersii* infection of the soft tissues, usually in the tongue.

INCIDENCE/PREVALENCE
Seen in up to 3% of cattle tongues at slaughter.

GEOGRAPHIC DISTRIBUTION
Worldwide.

SYSTEMS AFFECTED
- Digestive
- Musculoskeletal
- Integument
- Hemolymphatic

PATHOPHYSIOLOGY
- *Actinobacillus ligniersii* is a Gram-negative rod, which normally inhabits the alimentary tract of domestic ruminants, and is also found on plant awns.
- Musculosomatic lesions anywhere on the body, typically in the mouth, can be invaded by these bacteria, causing a localized lesion.
- Bacteria can also spread to different parts of the body via lymphatic drainage.
- A typical site of bacterial invasion is through small ulcers in the sulcus lingualis at the base of the tongue, leading to hard, painful, diffuse swellings.
- Lesions other than “wooden tongue” are usually uncommon; however, actinobacillosis should be included as a differential diagnosis for cutaneous diseases such as granulomatous dermatitis and lymphadenitis.

HISTORICAL FINDINGS
Abrasive feeds and crowded conditions may lead to sporadic herd outbreaks or endemic disease. Lesions outside the oral cavity may be associated with previous wounds or needle punctures.

SIGNALMENT
- Mainly cattle and sheep, occasionally goats
- All ages

PHYSICAL EXAMINATION FINDINGS
Cattle generally present with hyperaesthesia and tongue may protrude from mouth. Weight loss can be seen in more chronic cases due to inability to prehend feed. Tongue may be diffusely firm and immovable and nodular swellings may be present on the tongue or lips or within the pharyngeal region. If present in atypical sites, signs will vary.

CAUSES AND RISK FACTORS
Caused by infection of soft tissues by *Actinobacillus ligniersii*. Abrasive feeds, crowded conditions, surgical lesions, and other sources of trauma.

DIAGNOSIS

DIFFERENTIAL DIAGNOSES
- Pharyngeal trauma and abscessation
- Retropharyngeal lymphadenitis or lymphosarcoma
- Oral foreign bodies
- Dental disease
- Parasitic or foreign body granuloma
- Euoedema granulation tissue
- Contagious ecthyma and caseous lymphadenitis in sheep and goats

CBC/BIOCHEMISTRY/URINALYSIS
Chronic inflammatory profile

OTHER LABORATORY TESTS
Acute lesions: Culture and cytology of aspirates.

- Chronic: Biopsy/histopathology and culture of lesions.
- Microscopic examination of pus compressed between two glass slides shows “sulfur granule” or clublike rosette appearance with a central mass of Gram-negative rods.

PATHOLOGIC FINDINGS
Firm, pale, glistening, granulomatous abscesses with multifocal necrotic foci containing mononuclear cells, neutrophils, eosinophils, and plant fibers.

TREATMENT

Therapeutic Approach
- Sodium iodide 10% 70 mg/kg IV, once, repeat at least once at 7–10-day intervals.
- Organic iodides: 1 oz/450 kg PO daily following first IV administration above.
- Antimicrobials may be used alone or in conjunction with iodide treatment for severe cases.

Expected Course and Prognosis
- Fair to guarded prognosis if atypical sites are involved or lesions are chronic.

Follow-Up
- Good prognosis if only the tongue is involved and lesions are acute. Expect dramatic response to therapy in this case.
- Fair to guarded prognosis if atypical sites are involved or lesions are chronic.

Surgical Considerations and Techniques
May need surgical debulking of lesions in severe cases; however, note that access to the surgical lesion and close proximity to major vessels limit feasibility in some cases.

Medications

Drugs of Choice
- Sodium iodide IV
- Dally organic iodides PO
- Antimicrobials: sulfonamides, tetracyclines, ampicillin, streptomycin

CONTRAINDICATIONS
- Use sodium iodide with caution in pregnant cattle; see “Precautions.”
- Extra-label use of sulfonamides is restricted in lactating dairy cattle.
- Streptomycin is not labeled for use in food-producing species in some countries.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.
- Consult Food Animal Residue Avoidance Database (www.farad.org) for current withdrawal times. As of August 2015, suggested Milk and Meat withdrawal times for cattle treated with NaI as above were 96 hours and 1 day, respectively.

Precautions
- Anecdotal reports of association with abortion in cattle at high doses of sodium iodide.

Possible Interactions
N/A

Follow-Up

Expected Course and Prognosis
- Good prognosis if only the tongue is involved and lesions are acute. Expect dramatic response to therapy in this case.
- Fair to guarded prognosis if atypical sites are involved or lesions are chronic.

Possible Complications
Anecdotal reports of association with abortion in cattle at high doses of sodium iodide. If signs of sodium iodine (dandruff, excessive lacrimation, inappetence, coughing, diarrhea), halt therapy until signs disappear.

Client Education
Make aware of risk factors.

Prevention
Reduce access to abrasive feed and pastures with hard penetrating plant awns or thistles.

Miscellaneous

Zoonotic Potential
*Actinobacillus ligniersii* can contaminate bovine tissue and the milk supply. However, there is no evidence that it is a zoonotic agent.

Pregnancy
Anecdotal reports of association with abortion in cattle at high doses of sodium iodide.

Abbreviations
- IV = intravenous
- PO = per os
- NaI = sodium iodide

Sodium iodide is not approved for use in food-producing species. As of August 2015, suggested Milk and Meat withdrawal times for cattle treated with NaI as above were 96 hours and 1 day, respectively.
SEE ALSO
- Caseous Lymphadenitis
- Oral Disorders
- Oef (Contagious Ecthyma)
- Tongue Trauma

Suggested Reading
OVERVIEW

Common, sporadic, chronic granulomatous osteomyelitis of cattle caused by non-spor-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 abscess from cause other than Actinomyces bovis (movable, located in soft tissue)
- Impacted feed/foreign body between cheek and teeth (soft, movable)
- Lymphoedema/thrombosis (soft)

OTHER LABORATORY TESTS
- Culture: Deep samples should be taken and placed in anaerobic transport media.
- Microscopic examination of purulent debris: mix sample with saline and crush granules between slides. Gram stain will reveal Gram-positive organisms that may be branching, filamentous, coccoid or diphtheroid.

IMAGING
- Osteomyelitis of the affected area: teeth may be involved. Important to differentiate from tooth root abscess.

PATHOLOGIC FINDINGS
- Osteomyelitis with organisms present

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

MEDICATIONS

DRUGS OF CHOICE
- Penicillin, streptomycin, sulfonamides, erythromycin, and isoniazid have been used.
- Sodium iodide: 70 mg/kg IV every 3 to 5 days until signs of iodism occur (scaling skin, lacrimation, cough, anorexia).

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

CONTRAINDICATIONS
- Many historically used antibiotics are no longer approved in the United States.

EXPECTED COURSE AND PROGNOSIS
- Recrudescence is possible, even after prolonged periods of time.
- Difficult to treat. Early, aggressive treatment provides the best outcome.

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

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

PREVENTION
- Avoid feed or procedures that could cause oral lacerations.

AIDS TO DIAGNOSIS
- Monitor young cattle for swelling of mandible, especially following tooth extractions.
- Isolate cattle with discharging lesions. There is no vaccine.

MISCELLANEOUS

AGE-RELATED FACTORS
- Young cattle with erupting teeth

PREGNANCY
- Iodine treatment during pregnancy may cause abortion.

ABBREVIATION
- IV = intravenous

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

Suggested Reading

AUTHOR
- Dusty W. Nagy

Consulting Editor
- Christopher G.L. Chase

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**ACUPUNCTURE**

**OVERVIEW**
- Acupuncture is one of the four branches of traditional Chinese veterinary medicine (TCVM) and has been practiced for over 2,000 years.
- The twelve regular channels and the eight extraordinary channels connect acupoints all over the body. These pathways, known as meridians, relate to different organ systems and conduct the acupuncture signal and life energy, known as Qi.
- Techniques for stimulating acupoints include dry needling, aquapuncture, electroacupuncture, hemoeupuncture, and musculature.
- In 1997 the NIH (USA) released a consensus statement stating that acupuncture was proven to be effective for treatment of musculoskeletal pain, some gastrointestinal diseases, pulmonary disease, immunomodulation, and reproductive disorders in humans.
- Acupuncture is appropriate for use in organic production systems which are otherwise limited in their choice of treatment options.
- The practice of veterinary acupuncture is restricted to licensed veterinarians, or under the supervision of a licensed veterinarian, in most states and provinces in the US and Canada.

**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 and along the associated channels. Provides greater, longer-lasting stimulation of a point or channel than dry needling alone.
- **Acupuncture (AA):** Injection of sterile saline; vitamin B12, or the patient’s own blood into an acupoint. Provides longer-lasting stimulation of a given point than dry needling alone.
- **Hemoeupuncture (HA):** Release of blood from an acupoint; the point is pricked with a sterile hypodermic needle and allowed to bleed. Used to release excess heat or relieve stagnation.
- **Acupressure:** Applying pressure to an acupoint or along a meridian without insertion of a needle or other method of stimulation.
- **Musculature (moxa):** Sticks or cones of dried mugwort are burned and held near an acupoint or touched to a dry needle 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 along with suggested techniques. For explanation of the channel names and point locations, see “Suggested Reading.” It is strongly recommended that one completes a formal training program prior to performing any acupuncture treatment.

**EXPECTED COURSE AND PROGNOSIS**
- Improvement should be seen by the third treatment. Chronic or severe conditions will often require multiple treatments over an extended period (weeks to months).
- Although acupuncture can be used symptomatically, being able to make a Chinese medical diagnosis allows the practitioner to target the treatment towards the underlying pathologic process and will enhance results.
- Prognosis depends heavily on the severity and chronicity of the disease process, the patient’s temperament and demeanor, and the patient’s tolerance of acupuncture treatment.

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

**DRUGS OF CHOICE**
- Chinese herbal medications are sometimes given as a complement to acupuncture. Because of metabolism in the rumen and first compartment, oral doses should be 2 to 3 times greater than those listed for horses. Alternatively, the equine dose can be administered per rectum as a slurry.

**FOLLOW-UP**
- Please note that for emergencies (e.g., dystocia) acupuncture should not be used as any acupuncture treatment.
- Although acupuncture can be used symptomatically, being able to make a Chinese medical diagnosis allows the practitioner to target the treatment towards the underlying pathologic process and will enhance results.
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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 dexamethasone will blunt the response to acupuncture and should be used only when necessary.

AGE-RELATED FACTORS

- Neonates and juvenile patients respond readily to acupuncture, 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, the body may deplete what little is left for these patients, leading to death. Short treatments with very few needles should be used.

PREGNANCY

- 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 coccygeal vein.

ABBREVIATIONS

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

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.avacan.org/
- Chinese Veterinary Medicine: http://www.tcvm.com/
- Chi Institute (training available): http://www.tcvm.com/
- International Veterinary Acupuncture Society (training available): http://www.ivas.org/
- OneHealth SIM (training available): https://www.onehealthsim.org/
- World Association of Traditional Chinese Veterinary Medicine: http://www.wacvmed.org/

Author Christine M. Window
Consulting Editor Kaitlyn A. Lutz

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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.
- Infections 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.

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

PHYSICAL EXMINATION 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.
- Serum creatinine might be observed in urinemic animals.
- Severe cases develop muscular weakness and recumbency due to electrolyte and acid-base abnormalities.
- Renal palpation in cattle may reveal left renal enlargement.

CAUSES AND RISK FACTORS
- Conditions that result in systemic compromise, dehydration, and hypotension such as diarrhea, septicaemia, endotoxemia, disseminated intravascular coagulopathy, and acute blood loss.
- Nephrotoxic agents include heavy metals, aminoglycosides and tetracyclines, NSAIDs, toxic plants such as pigweed and oaks, vitamin C and D, tetracyclines, NSAIDs, toxic plants such as Leptospira spp. and urolithiasis.

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

TREATMENT

THERAPEUTIC APPROACH
- The animal should be removed from the source of the nephrotoxin or exposed to diuretics.
- Isotonic, sodium-containing IV fluids with added calcium and potassium should be administered every 2–3 hours to promote diuresis.
- Supportive care should include broad-spectrum antibiotics, rumen decontamination, 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.

FOLLOW-UP

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 transpeptidase
- IM = intramuscular
- IV = intravenous
- NSAIDs = nonsteroidal anti-inflammatory drugs
- SDH = sorbitol dehydrogenase

SUGGESTED READING

ACKNOWLEDGMENT
The author and book editors acknowledge the prior contribution of M.S. Gill.
BASICS

OVERVIEW
- Defined by the 1971 Agricultural Chemicals Regulation Law as "chemical agents such as fungicides and insecticides that are used to control crop-destroying organisms (e.g., fungi, nematodes, mites, insects, and rodents) or viruses (hereinafter collectively referred to as 'diseases and pests')."
- Also included are plant growth regulators and germination inhibitors.
- EPA regulates pesticides in the USA; it must be registered for use on food or feeds.
- 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 (cows and their calves).
- Agricultural chemicals are best classified by their specific application target:
  - Fungicides—control diseases 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 nonspecific.
  - Rodenticides—control mice, rats, and other small rodents.
- Rodenticides 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 organothiophosphate may not have been properly disposed of, posing a hazard to ruminants that may ingest them.
- Newer insecticides (i.e., pyrethroids and phenoxy herbicides) are safer and have replaced organophosphate and carbamate, but they are not without some harm to animals and the environment.
- Insecticides: Older products
  - Carbaryl, diazinon, aldicarb, malathion, parathion, methomyl, and others.
- Oxicarb, methiocarb, acephate, and others.
- Carbamates: aldicarb, carbaryl, and others.
- Organophosphate (OP) and carbamate compounds
  - DDT, chlordane, Dieldrin, lindane, malathion, parathion, methomyl, and others.
  - Carbamic acid, carbaryl, and others.
- Neonicotinoids
  - Imidacloprid, acetamiprid, clothianidin, and others.
- Neonicotinoids are highly toxic and no longer registered in the USA; still widely used worldwide.
- Insecticides: Newer products
  - Pyrethroids: cypermethrin, deltamethrin, others.
  - Carbamates: aldicarb, carbaryl, and others.
- Rodenticides: control mice, rats, and other small rodents.
- Rodenticides 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 organothiophosphate may not have been properly disposed of, posing a hazard to ruminants that may ingest them.
- Newer insecticides (i.e., pyrethroids and phenoxy herbicides) are safer and have replaced organophosphate and carbamate, but they are not without some harm to animals and the environment.

SYSTEMS AFFECTED
- Multysystemic, depending on chemical encountered

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 transplacental transmission.
  - Mammals: Older products
  - Carbaryl, dichlorvos, diazinon, lindane, parathion, and others.
  - Carbamates: aldicarb, carbaryl, and others.
- Neonicotinoids
  - Imidacloprid widely used worldwide in crop production.
  - Acetamiprid, dinotefuran, imidacloprid, oxadiazon, and others.
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Agricultural Chemical Toxicities (Continued)

- **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

- **FOLLOW-UP**

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

  - **POSSIBLE COMPLICATIONS**
    - Chronic poor production

- **DIAGNOSIS**

  - **DIFFERENTIAL DIAGNOSES**
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    - Nervous—lead poisoning, nervous ketosis, polioencephalomalacia, rabies (single animal)
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- **CBC/BIOCHEMISTRY/URINALYSIS**
  - Often unremarkable

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

  - **OTHER DIAGNOSTIC PROCEDURES**
    - Variable

  - **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.

  - **SLUDGE**—salivation, lacrimation, urination, diarrhea, gastroenteritis

  - **OPs**—organophosphorous insecticides

  - **SLUDGE**—salivation, lacrimation, urination, diarrhea, gastroenteritis

  - **Suggested Reading**

  - **INTERESTING RESOURCES**

- **AGRICULTURAL CHEMICAL TOXICITIES**

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

  - **ZOONOTIC POTENTIAL**
    - Meat and milk contamination.

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

  - **MISCELLANEOUS**

    - **ABBREVIATIONS**
      - CNS = central nervous system
      - DDT = dichloro-diphenyl-trichloroethane
      - EPA = Environmental Protection Agency

    - **Suggested Reading**
**AKABANE**

**A**

### BASICS

**Overview**
- Akabane virus (AKAV) is an arthropod-borne virus of ruminants.
- The virus is transmitted by small biting midges (or gnats) of the Culicoides species. 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 months. Outbreaks suggest that the fetus is infected in late gestation. Severe epizootics or smaller outbreaks are associated with movement of naive pregnant animals into an endemic area, or “spillover” of the vector from its region, or movement of naive 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, native 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 disease 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 Culicoides vector, viroemia occurs in the host 1–6 days later. The virus crosses the placenta and infects the fetus, leading to the clinical signs.
- Antibodies are detectable 14 days after infection. Infection between days 10–174 results in hydrencephaly. Infection between days 10–174 results in arthrogryposis with focal 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 32–48 days’ gestation resulted in fetal abnormalities. Ingoats, infection at approximately 40 days’ gestation resulted in fetal abnormalities.
- Infections in adult ruminants are typically asymptomatic. However, the fuki 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 paraparesis, and mild arthrogryposis. Group 4 lesions included arthrogryposis and hydrencephaly. Groups 3 and 5 were more severe manifestations of group 2 and 4 signs, respectively.
- Dyspnea may occur at parturition or abortion due to fetal abnormalities.

### GENETICS
- N/A

### 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 naive 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
- Bluetae virus
- Bovine viral diarrhea virus
- Boder disease virus
- Schmallenberg virus
- Cache Valley virus
- Ano virus
- Toxins, nutritional, or genetic causes of fetal neuromuscular defects

### OTHER LABORATORY TESTS
- Serology can be performed in affected dams and precolostral serum of the offspring.
- Collection of fetoplacental tissues at necropsy can be diagnostic via several molecular techniques, including reverse transcriptase real-time PCR, competitive ELISA, and immunohistochemistry/immunofluorescence.

### IMAGING
- N/A

### OTHER DIAGNOSTIC PROCEDURES
- N/A

### PATHOLOGIC FINDINGS
- The most common lesions are arthrogryposis and hydrencephaly.
- Other neurologic abnormalities may include ataxia, flaccid paralysis, and mild arthrogryposis.
- In the brain, degenerative and necrotic neurons as well as perineuronal and perivascular edema has been described.
- There may be loss of ventral horns of the spinal cord leading to hypoplastic spinal cord and muscle atrophy (e.g., torticollis). Pulmonary hypoplasia may also be noted.

### OTHER LABORATORY TESTS
- Serology can be performed in affected dams and precolostral serum of the offspring.
- Collection of fetoplacental tissues at necropsy can be diagnostic via several molecular techniques, including reverse transcriptase real-time PCR, competitive ELISA, and immunohistochemistry/immunofluorescence.

### IMAGING
- N/A

### OTHER DIAGNOSTIC PROCEDURES
- N/A
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

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
• Infection

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.

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.

ASSOCIATED CONDITIONS
Dystocia, retained placenta

AGE-RELATED FACTORS
AKAV affects fetal ruminants.

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).

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-hydranencephaly syndrome (AH syndrome)

ABBREVIATION
AKAV = Akabane virus

SEE ALSO
• Abortion: Viral, Fungal, and Nutritional
• Arthrogryposis
• Bluetongue Virus
• Border Disease
• Bovine Viral Diarrhea Virus
• Congenital Defects: Bovine
• Lupine Toxicity
• Schmallenberg Virus

Suggested Reading
Author Lisa Pearson
Consulting Editor Ahmed Tibary
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Anaphylaxis

Anaphylaxis is an acute systemic reaction that occurs following exposure of a sensitized animal to a specific antigen. This exposure results in urticaria, pruritus, and angioneurotic edema, followed by vascular collapse, shock and often life-threatening respiratory distress. Anaphylaxis has now been included under type I (immediate) hypersensitivity.

**OVERVIEW**

An anaphylactic reaction is a pathologic immune response that occurs following exposure of a sensitized animal to a specific antigen. This exposure results in urticaria, pruritus, and angioedema, followed by vascular collapse, shock and often life-threatening respiratory distress. Anaphylaxis has now been included under type I (immediate) hypersensitivity.

**INCIDENCE/PREVALENCE**

Sporadic, dependent on exposure to inciting antigens.

**SYSTEMS AFFECTED**

- Cardiovascular
- Respiratory
- Urinary

**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 vasodilatation and increased vascular permeability, and smooth muscles, causing contraction of the bronchi and respiratory distress.

**SIGNALMENT**

Bovine, ovine, and caprine; also reported in goats.

**PHYSICAL EXAMINATION FINDINGS**

Sudden, severe dyspnea, muscle tremors, anxiety, occurs within a few to 10–15 minutes following exposure to the antigen; muscle tremor may be severe and temperature may increase intramurally pressure to a point that normally sequestered milk components, notably caseins, 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 Diagnosis**

- Acute Bloat
- Acute Bronchopneumonia
- Acute Bronchitis

**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.

**TREATMENT**

**THERAPEUTIC APPROACH**

- Ancillary support of blood pressure (IV fluid) and respiration may be necessary.
- In dairy cattle that have been recently dried off, anaphylaxis may occur within a few minutes of their first exposure to the antigen. This exposure results in urticaria, pruritus, and angioedema, followed by vascular collapse, shock and often life-threatening respiratory distress. Anaphylaxis has now been included under type I (immediate) hypersensitivity.

**DRUGS OF CHOICE**

- **Anaphylactic shock** is treated with an injection of ephedrine. Ephedrine (1/100) substantially 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, flunixin meglumine (50 mg/mL) can be given at a rate of 1–2 mL per 100 lb. body weight IV or IM as well.
- Corticosteroids potentiate the effects of ephedrine and may be given following the administration of ephedrine.
- Amphotericin B may have effect once signs are present.

**EXPECTED COURSE AND PROGNOSIS**

Animals treated promptly usually return to normal within 12–24 h.

**PREVENTION**

Discuss the situation associated with the onset and duration of the reaction. 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**
Anaplasmosis is a hemoprotozoan disease caused by Anaplasma marginale affecting cattle. The disease is characterized by hemolytic anemia, hemoglobinuria, and fever. It is transmitted to cattle by ticks, primarily *Rhipicephalus* species. Infected ticks bite cattle, inoculating them with the pathogen. Clinical disease is most common in late summer and early fall, and it is more prevalent in cooler climates.

**Incidence/Prevalence**
Anaplasmosis is a relatively common disease in certain areas, particularly those with cooler climates, such as the northern United States and Canada. It is more prevalent in regions with cooler summers and colder winters.

**Geographic Distribution**
This disease is distributed worldwide, particularly in cooler climates such as the northern United States, Canada, and Europe. It is also found in Australia, South America, and Asia.

**Pathophysiology**
Anaplasma marginale is transmitted to cattle by ticks, primarily *Rhipicephalus* species. Infected ticks bite cattle, inoculating them with the pathogen. Clinical disease is most common in late summer and early fall, and it is more prevalent in cooler climates.

**Clinical Signs**
The clinical signs of anaplasmosis include fever, icterus, pallor, weakness, anorexia, and weight loss. Hemoglobinuria and hemoglobinemia are common, but not always present.

**Diagnosis**
Diagnosis of anaplasmosis is typically based on clinical signs, history, and serology. PCR and cELISA are commonly used for diagnosis.

**Treatment**
Treatment of anaplasmosis includes the use of antibiotics such as tetracycline, oxytetracycline, or imidocarb. Supportive care, such as fluid therapy and blood transfusions, may also be necessary.

**Prevention**
Prevention of anaplasmosis involves tick control measures. Vaccination is also available, especially in areas with a high prevalence of the disease.

**Client Education**
Owners should be educated on the symptoms of the disease and the importance of seeking veterinary care early in the course of the disease. They should also be aware of the importance of tick control and vaccination.

**Associated Conditions**
Other tick-borne diseases such as babesiosis and lyme disease can coexist with anaplasmosis, so it is important to consider these diagnoses as well.

**References**
- Author: Dusty W. Nagy
- Consulting Editor: Erica C. McKenzie
- Acknowledgments: The author and book editors acknowledge the prior contribution of Dawn J. Capucille.
Reduced Erythropoiesis
Nonregenerative Anemia Caused by
Hb molecule is made up of four heme groups, impair Hb synthesis.
causes bone marrow failure.
infiltration of the marrow with abnormal cells
deleted EPO production by the kidneys.
reduced erythropoiesis to damage by toxicants, irradiation,
causing alterations in iron metabolism and increased liver expression of hepcidin liver,
disease, or bone marrow failure can lead to
result from poor tissue oxygen delivery.
increased erythropoietin (EPO) production.
causing systemic tissue hypoxia and the capacity of the blood to transport oxygen,
absent.
basophilic stippling of RBCs) are minimal to
signs of bone marrow regeneration
reduced or defective erythropoiesis.
concentration, and/or packed cell volume (PCV)

PATHOPHYSIOLOGY
Iron is crucial to Hb synthesis because each
Iron (Fe) and copper (Cu) deficiencies can
Destruction of hematopoietic stem cells due to
Chronic inflammation is associated with
Chronic inflammation, chronic renal disease, or bone marrow failure can lead to
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
Weekness, lethargy, anorexia, weight loss, exercise intolerance, or synpotes
SIGNALMENT
Bovine, ovine, caprine, and camelid species

GENETICS
Congenital dyserythropoiesis is an autosomal recessive trait in polled Hereford cattle.

CAUSES AND RISK FACTORS
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.

NONREGENERATIVE ANEMIA

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
Multiorgan

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 Erythroplasms
Chronic inflammation, chronic renal disease, or bone marrow failure can lead to reduced erythropoiesis.
Chronic inflammation is associated with increased liver expression of hepatic 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 toxicants, irradiation, 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.

IRON DEFICIENCY
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
Weekness, lethargy, anorexia, weight loss, exercise intolerance, or synpotes
SIGNALMENT
Bovine, ovine, caprine, and camelid species

GENETICS
Congenital dyserythropoiesis is an autosomal recessive trait in polled Hereford cattle.

CAUSES AND RISK FACTORS
Nonregenerative Anemia Caused by Reduced Erythroplasms
Common causes of chronic inflammation include pneumonia, peritonitis, deep digital sepsis, liver abscesses, paratuberculosis, and lymphosarcoma.
Causes of chronic renal disease include pyelonephritis, amyloidosis, and glomerulonephritis.
Causes of bone marrow failure include severe inflammation or renal disease.
Counts can be caused by chronic

DIAGNOSIS
DIFFERENTIAL DIAGNOSES
Nonregenerative, normochromic anemia with normal to increased neutrophil and platelet counts can be caused by chronic inflammation or renal disease.
Nonregenerative, normochromic anemia with decreased neutrophil and/or platelet counts can be caused by bone marrow failure.
Macrocytic, hypochromic anemia with variably neutrophil and platelet counts can be caused by iron or copper deficiencies.
Macrocytic, normochromic anemia with variably 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 plethoric contraction (excitement, 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.
Hereditary coagulation factor deficiencies, hepatic steatitis, and hypothermia are often present in

Chronic inflammation or renal disease
Bacterial foci inclusions
Iron and copper deficiencies
Cobalt deficiency

Mechanism
Increased hepcidin or decreased EPO production
Cytotoxic damage to bone marrow
Defective
Defective DNA synthesis

Plasma protein
N ↑†
N ↓
N ↓
N ↓

PCV
↓↓↓
↓↓
↓
↓

MCHC
N
N
N
N

Neutrophil count
N ↑†
N ↓
N ↓
N ↓

Platelet count
N ↑†
N ↓
N ↓
N ↓

N = normal,
↓ = slightly decreased,
↓↓ = moderately decreased,
↓↓↓ = markedly decreased, and ↑ = slightly increased

Severe 10–13
Very severe <10

Chronic inflammation or renal disease
Bacterial foci inclusions
Iron and copper deficiencies
Cobalt deficiency


Anemia, Nonregenerative (Continued)

OTHER LABORATORY TESTS

<table>
<thead>
<tr>
<th>Chronic inflammation</th>
<th>Iron deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum ferritin</td>
<td>N  ↓</td>
</tr>
<tr>
<td>Bone marrow</td>
<td>N  ↓</td>
</tr>
<tr>
<td>Iron content</td>
<td>N  ↓</td>
</tr>
<tr>
<td>Total iron binding</td>
<td>N  ↓</td>
</tr>
<tr>
<td>Capacity</td>
<td>N  ↓</td>
</tr>
</tbody>
</table>

N = normal,  ↓ = decreased, and  ↑ = increased

- Azotemia, hypoalbuminemia, and proteinuria are often present with chronic renal disease.

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.

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.
- Reevaluation 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.

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
BASICS

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.
• Signs of bone marrow regeneration include reticulocytosis, polychromatosis, and basophilic stippling of RBCs.

INCIDENCE/PREVALENCE
• Extravascular hemolysis is more common than intravascular hemolysis. • Chronic copper toxicity occurs most commonly in sheep.
• Neonatal isoerythrolysis (NI) has been described in calves born to cows immunized with Anaplasma or Babesia vaccines. • NI has been described in lambs and kids following ingestion of bovine colostrum.

SYSTEMS AFFECTED
• Multi-systemic

PATHOPHYSIOLOGY
• Anemia is characterized by a reduced capacity of the blood to transport oxygen, leading to systemic tissue hypoxia and increased erythropoietin production. • 2–3 days are necessary for signs of bone marrow regeneration to be evident in the blood.
• Reticulocytosis usually peaks about 7–10 days after bone marrow stimulation.

Regenerative Anemia Caused by Blood Loss (Hemorrhagic Anemia)
• Causes of blood loss include trauma, surgery, coagulation factor deficiencies, thrombocytopenia, parasitism, and neoplasia.
• Regenerative response is usually higher with internal than external hemorrhage because some RBCs are reabsorbed by lymphatics and iron (Fe) is recycled.
• Chronic blood loss is usually associated with mild regenerative response and can lead to Fe deficiency.

Regenerative Anemia Caused by Accelerated RBC Destruction (Hemolytic Anemia)
• Accelerated RBC destruction (hemolysis) can occur within the blood vessels (intravascular) and/or outside of the blood vessels (extravascular).
• Extravascular hemolysis is more common than intravascular hemolysis. • Reticulocyte counts are usually higher in hemolytic anemia than in hemorrhagic anemia. • Onset of clinical signs is usually peracute to acute with intravascular hemolysis and more progressive with extravascular hemolysis. • Intoxia may develop in animals with hemolytic anemia secondary to increased Hb degradation and bilirubin formation. • Intravascular hemolysis is characterized by hemoglobinemia (free Hb in the plasma) that can lead to red discoloration of plasma and/or increased MCHC.
• 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 spleen or liver due to decreased RBC deformability or immune-mediated mechanisms. • Extravascular hemolysis does not cause hemoglobinemia or hemoglobinuria. • Causes of extravascular hemolytic anemia include erythrocytic or endolethelial parasites and congenital disorders.

PHYSICAL EXAMINATION FINDINGS
• Leptospirosis
• Ovalbumin, ovalbumin, and camelid species.
• Neonatal isoerythrolysis (NI) can occur in calves born to cows immunized with Anaplasma or Babesia vaccines and in lambs fed bovine colostrum.
• Chronic copper (Cu) toxicity occurs most commonly in sheep.
• Hereditary factor VII and IX deficiencies almost always occur in males.
• Anaplasmosis and babesiosis occur most commonly in adults.

PHYSICAL EXAMINATION FINDINGS
• Leptospira, uremia, and coldemid species.
• Pale mucus membranes
• Tachypnea and tachypnea • Heart murmur (due to reduced blood viscosity) • Intoxia
• Hemoglobinuria (with intravascular hemolysis)

GENETICS
• Hereditary factor VIII deficiency is an autosomal recessive trait in Hereford and Japanese Black cattle.
• Hereditary factor XI deficiency is an autosomal recessive trait in Holstein and Japanese Black cattle.
• Hemophilia A is an incoagulable dominant trait in pigs.
• Hereditary spherocytosis is an autosomal dominant trait in Japanese Black cattle.
• Congenital erythrocytrophic polychromatia 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) + Hematocrit abnormalities and factor VII or XI deficiencies + Moldy sweet clover and toadstool toxicosis
• Gastrointestinal ulcers
• Hemolytic bowel syndrome
• Thrombocytopenia
• Ruminant viral diarrhea virus infection
• DIC + Snake envenomation
• Trauma

Regenerative Anemia Caused by Chronic Blood Loss
• Gastrointestinal ulcers
• Chronic hemorrhage
• Severe fetotoxicosis + Urolithiasis
• Pyelonephritis
• Hereditary fibrinogenemia and factor VIII or XI deficiencies
• Parasites
• Internal (Harmonencho spp., Boophilus spp., Eimeria spp.) + External (blood sucking lice, fleas, ticks)

Regenerative Anemia Caused by Accelerated RBC Destruction
• Causes of Extravascular Hemolysis
• Intravascular parasitic
• Anaplasma centrofalcis and A. marginale in cattle + Theileria annulata, T. buffeli, T. parva in cattle – A. ovis and T. lestoquardi in small ruminants
• Epithrolytic parasitic
• Babesia spp., Babesia spp., and Babesia spp.
• Babesia spp., Babesia spp., and Babesia spp.
• Trauma + Enuretic sp., E. coli, and T. renebran in cattle
• Endothelial parasitic
• Toxoplasmosis (cat, dog, and T. renebran in cattle)
• Hemorrhagic bowel syndrome
• Hemodynamics + A. marginale, and T. caprae in cattle + A. ovis and T. renebran in small ruminants
• Hereditary spherocytosis
• Cause of Intravascular Hemolysis
• Bacterial infections
• Clostridium hemolyticum in cattle and sheep + Clavilin sphyfungium type A in cattle and sheep + Leptospirosis
• Osmostic lysis
• Overuse of hypertonic intravenous fluids
• Water intoxication
• Intravascular parasitic
• Babesia bigemina, B. bisonis, B. divergens, and B. major in cattle – B. tonisi and B. ovis in small ruminants
• Oxidative damage
• Bacteria spp. ingestion + Chronic Cu intoxication + Oak leaves and acorns ingestion + Onion or garlic ingestion + Red maple leaf ingestion + Selenium deficiency + Zinc toxicosis
• Primary immune-mediated disorders
• Neonatal isoerythrolysis + Incompatible blood transfusion
• RBC membrane alterations due to other mechanisms
• Congenital erythropoietic polychromatia + Postpartum hemoglobinuria + Snake envenomation

Anemia, Regenerative

Ruminant, Second Edition

35
ANEMIA, REGENERATIVE

OTHER LABORATORY TESTS

Hemorrhagic Anemia
- Examination of the skin and coat (external parasites)
- Fecal flotation (internal parasites)
- Fecal occult blood test (gastrointestinal ulcers)
- Coagulation tests (coagulation factor deficiencies)

Intravascular versus Extravascular Hemolysis

<table>
<thead>
<tr>
<th></th>
<th>Intravascular hemolysis</th>
<th>Extravascular hemolysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperbilirubinemia</td>
<td>can be present</td>
<td>usually present</td>
</tr>
<tr>
<td>Hemoglobinuria</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Plasma color</td>
<td>pink to red</td>
<td>straw to yellow</td>
</tr>
<tr>
<td>Hemoglobinuria</td>
<td>either present</td>
<td>No</td>
</tr>
<tr>
<td>Urate color</td>
<td>pink to red</td>
<td>straw to yellow</td>
</tr>
<tr>
<td>Blood reagent strip</td>
<td>positive</td>
<td>usually negative</td>
</tr>
<tr>
<td>Bilirubinuria</td>
<td>can be present</td>
<td>usually present</td>
</tr>
<tr>
<td>RBCs in urine sediment</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Chronic Copper Toxicosis
- Serum or plasma Cu concentration: >2 μg/ml
- Hepatic Cu concentration ≥350 ppm (dry matter basis)
- Renal Cu concentration >100 ppm (dry matter basis) (most reliable)

Lead Toxicosis
- Lead toxicity should be suspected when basophilic stippling if RBCs is accompanied by signs of inappropriate bone marrow regeneration (minimal polychromasia with nucleated RBCs).

Selenium (Se) Deficiency
- Blood Se concentration <50 ng/ml
- Blood glutathione peroxidase (GSH-Px) activity <15/mg/ml

PATIENT CARE
- Heart rate, respiratory rate, mucous membranes 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

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.

POSSIBLE Complications
- Iron deficiency anemia loss develops more quickly in young milk-fed animals because they have limited Fe stores.
(CONTINUED) 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 4–10 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
- GSH-Px = glutathione peroxidase
- 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 approved for use in the body are attenuated to different degrees sensory, motor, and autonomic functions of controlled but reversible depression of the body.

Pathophysiology
- General anesthesia is defined as a state of unconsciousness where the entire body is paralyzed and the cardiovascular, respiratory, and gastrointestinal systems are all affected.
- Cardiovascular system: general anesthesia produces immobility in 50% of patients from responding to a supramaximal stimulus (electrical stimulation of oral mucosa membrane). This is equivalent to the ED50 and corresponds to a light plane of anesthesia.

Minimum Alveolar Concentration
- 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 supramaximal stimulus (electrical stimulation of oral mucosa membrane). This is equivalent to the ED50 and corresponds to a light plane of anesthesia.
  - The ED95 is equal to 1.2 to 1.4 x MAC
  - The ED50 and corresponds to a moderate plane of anesthesia in 95% of patients.
  - There is some individual variation in MAC and inhalant dose should be titrated based on evaluation of the patient’s monitored anesthetic depth and physiologic parameters.
  - If adjuvivs anesthetics or analgesics are used, the MAC requirements may be reduced, therefore the inhalant should be titrated as stated above.

Signalment
- Potentially all ruminant species
- Recommended for sick patients with an ASA status of III or higher.
- 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
- Therapeutic Approach
  - Inhalational Anesthetics in Ruminants
    - Often not required if adequate restraint plus local or regional anesthesia is possible.
    - Fasting is recommended for all ruminants to minimize complications associated with recumbency and general anesthesia (e.g., pneumonia, ventilation/perfusion mismatch). The food and water fasting recommendations for calves, sheep, and goats are 12–18 hours and 8–12 hours respectively. The food and water fasting recommendations for adult cattle are 18–48 hours and 12–24 hours respectively. Neonates should not be fasted before anesthesia to avoid hypoglycemia.
    - Airway protection with auffed endotracheal tube is essential for injectable or inhalational anesthesia. Intubation in adult cattle is usually performed with a blind or digital palpation technique whereas small ruminants and calves can be intubated with a laryngoscope with a 250–300 mm blade.
    - The head and neck should be positioned to allow free flow of regurgitation from the mouth.
    - Padding and positioning of the patient are critical to prevent complications associated with neuropathy, myopathy, and injuries to the eyes.
    - An IV catheter is recommended for administration of anesthetic drugs or supplemental injectable agent doses.
    - Ruminants usually have smooth, controlled recovery from inhalational anesthetics as they do not experience emergence delirium like their equine counterparts. Extubation should only take place when swallowing reflexes have returned.

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

Medications
- Drugs of Choice
  - Isoflurane
    - The most common inhalant 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**
- 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: bradycardia, hypotension, hypothermia, and hyperventilation. 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.

**MISCELLANEOUS**

**AGE-RELATED FACTORS**
- Neonatal and geriatric animals will have exaggerated drug effects if standard drugs are used; therefore it is recommended to reduce the drug doses.
- Both have decreased respiratory and cardiac reserves so support of oxygenation, ventilation, and chronotropic or inotropic support should be expected.

**PREGNANCY**
- There are several physiologic alterations in pregnant animals including an increase in cardiac output, blood volume, oxygen consumption, and minute ventilation.
- In addition, gastrointestinal motility and esophageal sphincter tone can decrease as well as functional residual capacity.
- Therefore the anesthetist should be prepared to intubate with a cuffed endotracheal tube, ventilate, and support the pregnant animal.

**ABBREVIATIONS**
- ASA = American Society of Anesthesiologists
- CNS = central nervous system
- ED50 = effective dose 50
- ED95 = effective dose 95
- FARAD = Food Animal Residue Avoidance Databank
- IV = intravenous
- MAC = minimum alveolar concentration

**SEE ALSO**
- Alternative Medicine (see www.fiveminutevet.com/ruminant)
- Anesthesia: Injectable
- Anesthesia: Local and Regional Analgesia
- Pain Management (see www.fiveminutevet.com/ruminant)

**Suggested Reading**

**Author** Jennifer L Bornkamp
**Consulting Editor** Kaelyn A. Lutz


ANESTHESIA: INJECTABLE

**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 vein, 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**
- Worldwide

**SYSTEMS AFFECTED**
- Multisystemic
- Worldwide

**PATHOPHYSIOLOGY**
- Coughing reflexes.
- When the patient regains swallowing and endotracheal tube removed with cuff inflated

**SIGNALMENT**
- All ruminant species

**GENETICS**
- N/A

**CAUSES AND RISK FACTORS**
- Hypoxemia and pulmonary edema
- Severe hypoxemia and pulmonary edema can occur in sheep.
- In animals with urethral obstruction, rupture of bladder can result from increased urine output.
- Premature parturition has occurred in sheep.

**CONTRAINDICATIONS**
- Recommended dose ranges of yohimbine are
- Recommended dose ranges of atipamezole are
- Recommended dose ranges of xylazine are
- Order of breed variation of sensitivity to xylazine in cattle:
- Recommended dose ranges of ketamine are
- Recommended dose ranges of midazolam are
- Recommended dose ranges of diazepam are
- Recommended dose ranges of tolazoline's toxicity effect.
- Low recommended dose and slow IV injection should be used.

**POSSIBLE INTERACTIONS**
- Additive or synergic effect with other anesthetics.

**DIAGNOSIS**
- CBC/BIOCHEMISTRY/URINALYSIS
- May be indicated as preoperative workup.

**TREATMENT**
- N/A

**MEDICATIONS**
- 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. May precipitate if mix with water soluble solution.
  - Midazolam is water soluble with two to three times more potency than diazepam.
  - Diazepam or midazolam is used in goats with urolith 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
  - Recommended dose ranges of xylazine in cattle.
  - Recommended dose ranges of midazolam are 0.4 mg/kg IV.
  - N/A

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

**POSSIBLE INTERACTIONS**
- Additive or synergic effect with other anesthetics.

**Dissociative Anesthetics (Ketamine, Tiletamine)**
- Dissociative anesthesia is characterized by unconsciousness while maintaining eye reflexes (pupillary and corneal reflexes) and pharyngeal-laryngeal reflexes (swallowing reflex).
- Dissociative anesthetics cause direct CNS stimulation leading to increased sympathetic discharge and increased heart rate and arterial blood pressures.
- Respiratory pattern is characterized by an apneic, shallow, and irregular pattern.
- Ketamine is the most popular injectable anesthetic for large animals species.
- 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 2–5 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.

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## (CONTINUED) Anesthesia: Injectable

### Table 1

<table>
<thead>
<tr>
<th>Drugs</th>
<th>Cattle</th>
<th>Sheep &amp; Goats</th>
<th>Alpacas &amp; Llamas</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diazepam</strong></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><strong>Diazepam</strong></td>
<td>0.1, IV</td>
<td>Mix 1 mL D (5 mg), 1 mL K (100 mg), give 1 mL/18–22 kg, IV</td>
<td>0.1–0.2, IV 4, IV</td>
<td>Anesthesia 10–15 min Total recumbency 30 min</td>
</tr>
<tr>
<td>Ketamine</td>
<td>4.5, IV</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Medetomidine</strong></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><strong>Midazolam</strong></td>
<td>—</td>
<td>0.4, IM 4, IV</td>
<td>—</td>
<td>Anesthesia 15 min</td>
</tr>
<tr>
<td>Ketamine</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Butorphanol</strong></td>
<td>0.0375, IM</td>
<td>1 mL/23 kg, IM; 1 mL/45 kg, IV</td>
<td>Alpacas: 1 mL/78 kg, IM Llamas: 1 mL/23 kg, IM</td>
<td>Anesthesia 20–30 min Mixture: add 0.05 mL LA X (100 mg), 1 mL B (10 mg) into 10 mL K (1,000 mg), give 1 mL/20 kg IM</td>
</tr>
<tr>
<td>Ketamine Xylazine</td>
<td>3.75, IM</td>
<td>0.35–0.8, IM 3–5, IM</td>
<td>0.15–0.25, IV 3–5, IV</td>
<td>5–8, IM 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>Modified BKX</td>
<td>—</td>
<td>—</td>
<td>—</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>Butorphanol</td>
<td>0.02 mL/kg, IM</td>
<td>0.03 mL/kg, IM</td>
<td>0.03 mL/kg</td>
<td>—</td>
</tr>
<tr>
<td>Ketamine</td>
<td>1.6, IV</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.03 IM</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Bovine Triple Drip</td>
<td>Induction: 0.67–1.1 mL/kg Maintenance: 2.2 mL/kg/hr</td>
<td>Induction: 0.67–1.1 mL/kg Maintenance: 2.2 mL/kg/hr</td>
<td>Induction: 0.67–1.1 mL/kg Maintenance: 2.2 mL/kg/hr</td>
<td>Adjusted dose for induction &amp; maintenance Stable plane of anesthesia Smooth recovery</td>
</tr>
<tr>
<td>Xylazine</td>
<td>4–6, IV</td>
<td>Induction: 3–4, IV or 4–8, IV Maintenance: 18–40 mg/kg/hr</td>
<td>Induction: 3–3.5, IV Maintenance: 24 mg/kg/hr</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>Ketamine</td>
<td>(1–2 mg/mL) into 5% Guaifenesin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Propofol</strong></td>
<td>4–6, IV</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Telazol</td>
<td>4, IV 2–4, IV</td>
<td>2, 4 or 4.4, IM</td>
<td>Anesthesia 45–60 min Smooth but prolonged recovery</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.1, IM</td>
<td>—</td>
<td>0.25, 1, IV</td>
<td>Anesthesia 60 min Standing in 130 min</td>
</tr>
<tr>
<td>Telazol</td>
<td>4, IM</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td><strong>Telalol</strong></td>
<td>1.25–1.5 mL/125 kg, IM for small cattle</td>
<td>1.25–1.5 mL/125 kg, IM for smaller patients 1 mL/110–115 kg, IM for larger patients</td>
<td>Allow 20 min to reach peak effect Effective for capture wild ruminants Deep sedation, recency and chemical restraint in camels; awake and assume sternal recency in 40–60 min</td>
<td></td>
</tr>
<tr>
<td>Ketamine</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>1 mL/125 kg IM for large, adult cattle</td>
<td>—</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>
**Anesthesia: Injectable**

**Recommended Dose Ranges of Telazol®**

- 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.

**POSSIBLE INTERACTIONS**

Adjuvant or synergistic effect with ketamine.

**Guaifenesin (Glycerol Guaiacolate; GG)**

- **Administered alone, GG produces muscle relaxation, ataxia, and recumbency.**
- **Minimal changes on respiratory muscle activity and respiratory function 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**

If used in combination with α2-antagonists, GG does not produce anesthesia or analgesia.

**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: Induction
- Anesthesia: Local and Regional
- Common Pharmacologic Therapies: Adult Dairy Cattle

Suggested Reading


Internet Resources


**Author** HuiChu Lin

**Consulting Editor** Kaitlyn A. Lutz
Dehorning, Ovine and Caprine

There are 2 or 2 nerves to block in sheep and goats.
- **Cornual branch of the lateral ventral nerve:** 2.5 cm, 22G needle with 1–2 mL 2% lidocaine injected SQ halfway between the lateral canthus and lateral edge of the horn base.
- **Cornual branch of the infraorbital nerve:** 2.5 cm, 22G needle with 1–2 mL 2% lidocaine injected SQ halfway between the medial canthus and the medial edge of the base of the horn.

**Anesthesia of the Eyelid and Eye**
- **Auriculopalpebral block, bovine, ovine, caprine:** 2.5 cm, 22G needle with 5 mL 2% lidocaine in ovine and caprine) 2% lidocaine injected SQ on the dorsal zygomatic arch about 5–6 cm behind the infraorbital process.
- **Retractor 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. **Ornix 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.
- **Peterson block, bovine:** 10–12 cm, 20G needle with 15–20 mL of 2% lidocaine. The needle is passed thru the skin at anterior edge of TP of L1, 4–5 cm from dorsal midline. The spinal needle is directed at a 45° angle in small ruminants.

**Anesthesia of the Nasal Passages**
- **Infraorbital block, bovine, ovine, caprine:** 3.8 cm, 16G needle with 5–20 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 prepared 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 8.9 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 until it contacts the L1 TP and walked off the cranial edge; as it passes thru the transverse ligament inject 6–8 mL for the ventral branch. Then withdraw the needle to 2.5 cm over the fascia and deposit an additional 6–8 mL for the dorsal branch.
- **Distal paravertebral block, bovine:** Same technique with a 2.5–3.8 cm, 20G needle with 0.5–1 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, ovine:** The area of the block is clipped and prepared 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 reinseted dorsally and LA is infused caudally in a fan pattern as well. Repeat at the other sites.

**Anesthesia of the Linea Aba and Paramedian Region**
- **Canal (anterior or posterior) epidural block, bovine:** Not recommended as LA infiltration will cause motor blockade of the pelvic limbs preventing ability to stand. **Ornix 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 0.4–0.6 mL/kg of 2% lidocaine will provide anesthesia up to the navel region.

**Anesthesia of Pelvic Area**
- **Caudal (anterior or posterior) epidural block, bovine:** The space is located between S5-Co1 or Co1-Co2 and is easily palpable while moving the tail up and down. You will feel this as the space between the last anchored and first movable vertebrae. A 3.8 cm, 20 or 18G needle is passed on midline at a slight cranial angle into the vertebral space. Check placement with hanging drop technique. A dose of 0.01–0.02 mL/kg of 2% lidocaine can be used. **Ornix and caprine:** The technique is the same with a 3.8 cm, 20G needle at S4-Co1 or Co1-Co2 with an injection volume of 0.01–0.03 mL/kg. The needle is directed 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 tear sinus infusion blocks. A proximal or distal paravertebral block extending from T13 to L4 can be used to block a majority of the udder.

**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.

**MEDICATIONS**

**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.

**SEE ALSO**

- Alternative Medicine (see www.fiveminutevet.com/ruminant)
- Anesthesia: Inhalation
- Anesthesia: Injectable
- Castration/Vasectomy: Bovine
- Castration/Vasectomy: Camels
- Castration/Vasectomy: Small Ruminants
- Dehorning
- Enucleation/Exenteration (see www.fiveminutevet.com/ruminant)
- Pain Management (see www.fiveminutevet.com/ruminant)

**Suggested Reading**


Ruminant, Second Edition

**Overview**

Anestrus is the absence of estrus behaviors in female animals.

- Anestrus is physiologically 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 missed, due either to deficiencies in management (unobserved 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 postpuberal ovulation in ruminants.
- Animals experiencing pathologic anestrus are usually anovular 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 (unobserved estrus), subtle or absent signs of estrus (silent heat/subestrus), or both. The size and duration of estrus behavior may also be reduced or absent altogether at the first postpartum, seasonal or postpuberal ovulation in ruminants.

**Pathophysiologic**

- 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 deviation 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 inadequate 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 lowered estradiol concentrations 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, significantly reduced number of newborn, or decreased pup survival.

**Signalment**

- Sexually mature (postpuberal) female animals.
- Specific conditions vary with species and breed depending on nutrition, milk production levels, reproductive management systems, suckling intensity, seasonal (photoperiodic) 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 OCD.
- Long dry periods.
- Twin calving/Freemartinism.
- Primary uterine or fetal disease (e.g., pyometra, hydrodema [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, myxostomias, and micronutrient deficiencies.

**Diagnosis**

**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.
- Freemartinism.
- Inadequate estrus detection/reproductive 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/history.
- Observation for sexual activity as appropriate for each species.

**Pathologic Findings**

- N/A
ANESTRUS

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.

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.
- Decreased dry period length for older cows.

MISCELLANEOUS

ASSOCIATED CONDITIONS

- Pyometra
- Endometritis
- Twinning
- Lameness
- Starvation
- Heat stress

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 invariably (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
- OCD = 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

Overview

- Angular limb deformity (ALD), “limb-lag,” 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.

- Varus deformity: The limb deviates laterally.

- Valgus deformity: The limb 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 flexural deformities, tendon injuries, joint luxations/joint instability caused by laxity of supporting structures, and rotational/torsional 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

- Varus and valgus 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: toxemia, placentitis, lability of periarticular 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 forlorn-valga deformities in llamas. The ulnar epiphysis extends distally, crosses the radial epiphysis, and fuses with the radial epiphysis. This early fusion demands synchronous growth to ensure normal limb development.

- Most calves have a mild carpal valgus deformity of approximately 7 degrees, which does not require treatment. Varus deformities in cattle are abnormal and often require treatment.

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 cria).

- 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 call (Giraffa camelopardalis).

Breed Predilections

- ALDs have been described in many different breeds and dairy cattle breeds.

- HC primarily affects black-faced breeds of sheep (Suffolk, Hampshire, Southdown, Shropshire, and Oxford)

- Varus/valgus deformities have been described in the distal radial physes of earing farmed male red and white-sired console (ide) 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 ALDs).

- 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 bowlegged. All limbs should be palpated and affected limbs should be manually manipulated. Clinical signs such as abnormal bending of the affected limbs, 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.

- Varus deformity is found unilaterally, the contralateral limb should be examined for a significant orthopedic injury as a cause of excessive weight bearing on 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, pectus excavatum, retarded growth rates, facial deformities such as angular deviation and/or shortening of maxilla, rounding of the dorsal silhouette, and Roman-shaped noses.

Genetics

- The question of heritability in ALDs has 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 physis, ligament rupture, or orthopedic injuries.

- Congenital Predisposing Factors

- Incomplete cuboidal bone ossification (cuboid and/or tarsal).

- Physiologic immaturity at birth.

- Uterine malpositioning.

- In utero bending stress and bone remodeling early in gestation.

- Twin (or triplet) pregnancy.

- Reduced intrauterine space (fetal movement space).

- Subsequently cause congenital angular and/or flexural limb deformities.

- Laxity of periarticular supporting structures.

- Disproportionate osteous growth of medial and lateral aspects of long bones (e.g., distal radius, tibia, metatarsus).

- Nutritional imbalance during gestation.

- Genetic 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; Salter-Harris fractures, malunion of fractures, infarction of growth plate).

- Iatrogenic (e.g., assisted delivery).

- Excessive exercise.

- Hemorrhagic osteomyelitis involving the physis region.

- Rapid weight gain in heavy breeds (high energy rations and rapid growth).

- Often, no specific cause is identified.

Camelids

- May see ALDs (usually cuboid varus) in growing camels with hypophosphatemic rickets syndrome.

- IL-6 syndrome in llamas may be associated with ALDs as well as anemia, low serum iron concentrations, and metabolic disorders (hyperthyroidism).

Underlying cause not established.
**ANGULAR LIMB DEFORMITY (CONTINUED)**

## DIAGNOSIS

### DIFFERENTIAL DIAGNOSES
- Physiologic deformities
- Metabolic bone disease (e.g., rickets)
- HC may be confused with arthropathy-hydranencephaly syndrome (AHS) in lambs, in which there is characteristic hyperplasia of foalbuds, 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 ataxic deformities of the forelimbs in newborn cria that self-correct without surgical treatment.

### CBC/BIOCHEMISTRY/URINALYSIS
- There are usually no associated laboratory abnormalities with ALD.
- HC results in slightly elevated serum alkaline phosphatase and/or liver function tests.
- 25-hydroxycholecalciferol concentrations are often diagnostic. May also see hypothyroidism, anemia, erythrocyte hydration and others) and not of the syndrome (AHS) in lambs, in which there is 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.

### OTHER LABORATORY TESTS
- N/A

### IMAGING
- Radiographs are critical in diagnosing ALDs—at least two views, 90 degrees apart, should be taken from the affected joint, including joints immediately proximal and distal to the affected joint.
- The dorsopalmar/dorsoplantar (DP) 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 dorsopalmar 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 anconel process and malformed, displaced sternocleidomastoid. The anconel lesions of HC are progressive, whereas similar lesions in other skeletal conditions of lambs regress.

### OTHER Diagnostic PROCEDURES
- Bacterial cultures may be indicated in cases of septicemia, arthritis, or osteomyelitis.
- Toxicology (heavy metal and mineral analysis) and feed analysis may assist in diagnosis.

## PATHOLOGIC FINDINGS
- Histology: Focal or segmental thickening of the phys (expansion of the hypertrophic zone) with extension into the proximal metaphysis, closely resembles physical manifestations of osteochondrosis.
- 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 if the animal does not damage the affected physis or joints with vigorous exercise.
- Specific treatment methods are selected on the basis of age, degree of angulation, remaining growth potential of the involved physis, and experience of the veterinarian.
- Minor limb deviations 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 metacrylate) wedge 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 varus deformity is present secondary to a contralateral limb injury.

### SURGICAL CONSIDERATIONS AND TECHNIQUES
- Surgery is recommended for older animals (near the end of active physical 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.

### 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 of the physis, the veterinarian may elect to redirect the physis to correct the deviation by physical growth.

#### Growth Retardation (Transphyseal Bridging)

- Tranphyseal bridging is indicated for severe cases of ALD or in animals past the rapid growth phase of the radius and ulna (often recommended for animals older than 5 months of age).
- By creating a temporary transphyseal bridge on the convex side of the deformity using staples or screws and wires, limb growth is slowed by restricting growth 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 periosteal 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 often reserved for valuable animals when response to other therapies has failed.
- The site and orientation of the wedge are 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 ulcer ostectomy must be done in conjunction with the periosteal transection 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 use has been associated with gastrointestinal (abomasal or C3) ulcers.

#### PRECAUTIONS

- Many of these affected animals are young; precautions regarding drug choices must take age into consideration.
- Appropriate milk for young animals is recommended.
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
- Prognosis is guarded, yet reasonable for ALDs associated with growth plate imbalances, such as in llamas with ALDs. 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, 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.

MISCELLANEOUS

ASSOCIATED CONDITIONS
- Conditions associated with ALDs include osteochondrosis of the physis, epiphysis, and incomplete ossification of the cuboidal carpal bones. • Hyena 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 = “Debrec echondysplasia.” • Congenital chondrodysplasia dwarfism in Holstein calves. • Complex vertebral malformation is a familial syndrome of Holstein calves. • Syndrome known as “hunched” or “bowie” associated with ingestion of *Trachymene glaucifolia* (sild pasque) 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 (hormones, 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
- AHS = acute hereditary chondrodysplasia syndrome
- ALD = angular limb deformity
- AVE = central nervous system
- DP = dorsoplantar/dorso plantar
- FGFR3 = fibroblast growth factor receptor 3
- HC = osseous hereditary chondrodysplasia
- NSADs = nonsteroidal anti-inflammatory drugs

See Also
- Arthrogryposis
- Congenital Defective Bone
- Hereditary Chondrodysplastic Ovine
- Lameness (by species)

Suggested Reading
- Authors Erik J. Olson and Nicholas A. Robinson
- Consulting Editor Kathlyn A. Lutz
- Acknowledgment The authors and book editors acknowledge the prior contribution of Cathy S. Carlson.

(Continued)
Anthelmintic Resistance

BASICS

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 Osteopelmaestrzy 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 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 pressure of anthelmintic treatment is applied.

PATHOLOGIC FINDINGS
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 one compound 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 hepatoportal cirrhosis are prominent signs.

OTHER LABORATORY TESTS

The standard by which parasite loads are measured is the assessment of fecal egg counts. 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 nematodes. Producers have used dewormers in a very cavalier manner over the past 40 years.

MEDICATIONS

CLIENT EDUCATION

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 nematodes. Producers have used dewormers in a very cavalier manner over the past 40 years.

ANTHelmintic Resistance
Anthelmintic Resistance

(Continued)

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 infection 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: Camelid
• 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
**Anthrax**

### BASICS

**OVERVIEW**
- Anthrax is a bacterial disease that many animals are susceptible to including humans.
- In ruminants it causes acute bacteremia, septicaemia, and usually death. 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 disruption of the soil.
- Morbidity varies widely but case mortality is 90–95%.

**GEOGRAPHIC DISTRIBUTION**
- Anthrax is found worldwide but certain regions have higher occurrence of disease.
- Anthrax spores favor areas with neutral to alkaline soils with high levels of calcium and manganese and are organically rich.

**PATHOPHYSIOLOGY**
- Soil-borne spores are the infective form of the bacteria.
- Animals residing in endemic pastures or feeding on affected carcasses.
- The heart has a dull appearance and is flaccid.
- Blood is usually thick and dark red with little or no clotting.
- The spleen can be greatly enlarged and bloody.
- The lungs are congested, swollen, and soft. The spleen is commonly forms chains.

**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 toxicosis (cyanobacterium), and blastomycosis.

**OTHER DIAGNOSTIC PROCEDURES**
- Samples must be submitted for a definitive diagnosis.

**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.
- Sporation 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.

**TREATMENT**

**SIGNALMENT**
- 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, 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.
- The laboratory should be forewarned of a diagnostic submission. Bloody fluids and exudates coming from any of the body orifices.
- Microscopic examination of blood smears, bacterial cultures, and PCR are a few of the examinations laboratories use to identify *Bacillus anthracis*.

**PATHOLOGIC FINDINGS**
- If the carcass is inadvertently opened the lesions are those of septicaemia.
- Rigor mortis is commonly not present or incomplete.
- Cattle that die of anthrax decompose rapidly and are found gas distended with bloody exudates coming from any of the body orifices.
- Blood is usually thick and dark red with little or no clotting. Any clotted blood found is not well formed.
- Multifocal hemorrhages are common on mucosal and serosal surfaces as well as subcutaneously.
- Gelatinous fluid accumulates in loose connective tissue and serous cavities and could be blood tinged.
- Paranchymatous organs are congested, swollen, and soft. The spleen can be greatly enlarged and bloody.
- The heart has a dull appearance and is flaccid.
- In cattle the lesions at the site of bacterial entry can be more severe, such as ulcerative hemorrhagic enteritis.
- If the bacteria come in through the oropharynx there will be hemorrhage and swelling of local lymph nodes as well as edema in adjacent connective tissue and throat.
- Likewise if there is a case of pulmonary anthrax in cattle, lesions would be more severe in lung and mediastinum.
- Sheep and goats are more susceptible to anthrax than cattle. The course of the disease is more rapid so some of the lesions maybe less prominent or missing.

**DRUGS OF CHOICE**
- *B. anthracis* is generally antibiotic-sensitive but some strains can be resistant to penicillin.
- *B. anthracis* is susceptible to many antibiotics.
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
**Arsenic Toxicosis**

**OVERVIEW**
- Arsenic is the second most common cause of heavy metal intoxication of cattle, after lead.
- Arsenic is still used in herbicides, defoliants, and other products.

**CAUSES AND RISK FACTORS**
- Exposure or access to arsenic-containing products or residues such as herbicides, insecticides, and the ashes of plants.
- Arsenic is most often toxic when ingested, though cutaneous absorption has been documented.
- Ruminants are particularly sensitive to the aliphatic arsicals MSMA and DMSA which are used as herbicides.
- 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.

**DIAGNOSIS**
- **PHYSICAL EXAMINATION FINDINGS**
  - Signs typically reflect acute toxicosis and can include:
    - Diarrhea
    - Weakness
    - Anorexia
    - Colic
    - Dehydration
    - Anemia
    - Hemorrhage

- **HISTORICAL FINDINGS**
  - Deliberate or accidental exposure to products containing arsenic.

**PATHOLOGIC FINDINGS**
- Gross findings include:
  - Swollen liver and kidneys
  - Coagulative necrosis of the gastrointestinal mucosa
  - Sloughing of the mucosal lining into the gut lumen
  - Hemorrhage

**TREATMENT**
- **THERAPEUTIC APPROACH**
  - Recently exposed animals may benefit from measures to reduce further ingestion and absorption of arsenic.
  - Effective treatment of clinically affected animals relies on supportive medical care in addition to targeted chelation therapy.

**DRUGS OF CHOICE**
- Absorption from the rumen after recent ingestion may be reduced via administration of mineral oil, or by rumen gavage or rumenotomy.
- Chelation therapy can be attempted using:
  - Sodium thiosulfate—IV: 30–40 mg/kg PO: 20–30 g in 300 mL water (cattle) or 5–7.5 g in sheep and goats given q12h or q6h for 3–4 days.
  - Penicillamine (may be cost prohibitive)—10–50 mg/kg PO q8h–q6h for 3–4 days.
  - 2,3-dimercaptopropanoic acid (DMSA)—a water-soluble analog of dimercaptopropane—10 mg/kg PO q8h for 3–4 days.
  - Dimercaprol—known as British anti-lewisite (BAL) and is recommended for treating trivalent inorganic or aliphatic organic arsenic toxicosis.

**CONTRAINdications**
- Absorption from the rumen after recent ingestion should be identified to reduce human risk.
- Care should be taken to avoid environmental contamination.
- Appropriate milk and meat withdrawal times must be followed for all compounds administered to food-producing animals.
**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

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**ZOONOTIC POTENTIAL**
N/A

**PREGNANCY**
Pregnant animals may abort.

**BIOSECURITY**
N/A

**PRODUCTION MANAGEMENT**
N/A

**SYNONYMS**
N/A

**ABBREVIATIONS**
- BAL = British anti-lewisite
- BVDV = bovine viral diarrhea virus
- DMFA = 2, 3-dimercaptopropanoic acid
- DSMA = dimethylarsinic acid
- HSMA = 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 Rodol.
Arthrogryposis

Basics

Overview
Arthrogryposis is not a specific diagnosis, but rather a clinical finding of congenital contractures, which 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 carpal and tarsal joints are most commonly affected, followed by metacarpophalangeal and metatarsophalangeal joints.

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

The arthrogryposis-hydranencephaly 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 club 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 breed.

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).

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, prenatally acquired 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 Oxytropis spp. (locoweed); Verratrum californicum (skunk cabbage); piperidine alkaloid-containing plants such as Lupinus, Canvium, and Nicotiana species.

Repeated dosing 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-motoneurons in the cervical spinal cord are significantly reduced.

May cause disruption in normal innervation of muscles leading to paralyse 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, birthing details, age at which the deformity was noticed, course and progression of deformity, does 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 Predictions

Certain syndromes are predominantly reported to occur in certain breeds (e.g., congenital arthrogryposis in Charolais cattle). CCD has been observed in most dairy breeds and in all breeds of beef cattle common to western North America.

No breed predilection or genetic susceptibility in cattle to the lupine-induced condition has been determined.

Mean Age and Range
Arthrogryposis tends to affect young, growing animals. The incidence of CCD is highest in heifers at first calving, but the disease has been observed in calves from cows of all ages.

For each species (calf, sheep, and goat), there are specific periods of gestation when the fetus is susceptible to plant teratogens.

The critical gestational period for exposure of cattle to lupines is 40–70 days with susceptible periods extending to 100 days.

Predominant Sex
No apparent sex predisposition

Physical Examination Findings

The animal’s conformation should be assessed first by having the animal stand in a symmetrical manner on a firm flat surface and observing it from multiple angles.

Arthrogryposis in CCD is characterized by deformities of the limbs (rigid flexion of elbows and carpal joints) and spinal column (scoliosis, lordosis, kyphosis), and rib cage abnormalities. Affected calves occasionally have torticollis and club feet.

The joints are often flexed and cannot be extended even after the flexor tendons are cut—distinguishing the disease from contracted tendons.

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.

Syndromes in Charolais, Friesian, 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 intrauterine infections with Border disease virus, BVDV, Akabane virus, Cache Valley virus, bluetongue virus, Aino virus, Kasba (Chuvash) 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

Urinary malpositioning

Genetic causes

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

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

- Leg deformities in young calves are most commonly associated with congenital contraction of the tendons. Flexural 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 arthrogryposis.

### 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 inability to stand.

### Differential Diagnoses

- Arthrogryposis and CCD differ from congenital arthrogryposis in animals with contracted tendons; the joints are usually properly aligned and the legs are not rotated. In calves with arthrogryposis, the articular and osseous changes are usually permanent and worsen as the calf grows.

### Imaging

- Radiographs can be used to diagnose ALDs; at least two views, 90 degrees apart, should be taken of the affected joint.
- The dorsopalmar/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 Laboratory Tests

- CBC/Biochemistry/Urinalysis

### Other Diagnostic Procedures

- Serology and virologic diagnostic assays may aid in ruling out exotic 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

- A syndrome known as "bentleg" or "bowie" has been associated with ingestion of *Trachymene glaucifolia* (wild parsnip) by pregnant ewes in Australia and New Zealand.
- Coordinate grazing times and alter breeding dates to minimize exposure. Avoid grazing potentially teratogenic plants when pregnant cows are at the susceptible stage of pregnancy.

### Treatment

**Therapeutic Approach**

- Severely affected animals may be unable to rise to nurse and require additional supportive care.
- Protect joints with thick, soft bandages that are well confined to 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 septicemia.
- 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 obtain 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.

### Medications

- **Drugs of Choice**
- **Contraindications**
- **Precautions**
- **Possible Interactions**
- **Alternative Drugs**

### 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 dates to minimize exposure. Avoid grazing potentially teratogenic plants when pregnant cows are at the susceptible stage of pregnancy.
- Control teratogenic plant populations with herbicides.

### Miscellaneous

- **Associated Conditions**
- A syndrome known as "bentleg" or "bowie" has been associated with ingestion of *Trachymene glaucifolia* (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.
Arthrogryposis (Continued)

**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 chondroplasia
- IFR = 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
- Wesselbron 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

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Artificial insemination (AI) is the aseptic collection and cryopreservation of semen for use in cattle. AI is more prevalent in dairy cattle than beef cattle. The quality of frozen-thawed semen depends on initial quality at production, handling during storage, thawing procedures, and interval until deposition into the uterus. The cryopreservation process varies slightly depending on extender and technique used.

**Factors Affecting AI Success**

**Quality of Semen**

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 catastrophic injury or terminal illness. Semen collected with an AV presents better post-thaw motility than semen collected with electroejaculation.

Although fresh/cool 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.

**Pathophysiology**

The quality of frozen-thawed semen depends on initial quality at production, handling during storage, thawing procedures, and interval until deposition into the uterus. 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.

**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 transcervical 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 utrinate 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 (Continued)

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:
  - Insemination 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 unskilled or inexperienced technicians.

PATIENT CARE
Appropriate estrus detection and handling to reduce stress.

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
N/A

PREGNANCY
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
- IBR = 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
- Gibbons. 43: 338–46.
- Author Alexis Campbell
Artificial insemination: Small Ruminant

OVERVIEW

- Artificial insemination (AI) is used in sheep and goats to improve genetics, improve reproductive efficiency, reduce distance transmission, and permit out-of-season breeding.
- Success of an AI program is affected by several factors including timing, semen quality, and semen placement.
- For economic reasons, except in a few cases (dairy goat), most AI is performed at a fixed time following synchronization of estrus.

PHYSICAL EXAMINATION FINDINGS

- Females to be inseminated should be in estrus.
- Estrus detection may be performed with a teaser male (sheep and goat) or by visual observation (goat).
- Females in estrus will show typical receptive behavior. Does express estrus more intensely than ewes (tail fanning, mounting other females, and standing to be mounted).
- Only high-quality ejaculates are used. Semen is diluted in one of a variety of available commercial extenders (milk-based, egg yolk-based, or new chemically defined soybean lecithin-based).
- Milk-based extenders are commonly used for fresh, chilled (4°C) or cooled (15°C) semen insemination. Skim milk or UHT-treated milk is used in order to remove lactenin which is spermicidal.
- Tri-based egg yolk extenders are used routinely for cryopreservation. However, egg yolk is toxic to buck semen because of the presence of lupin produced by the bulbourethral gland (BUSgp60). Buck semen needs to be washed prior to addition of egg yolk-based extender. An alternative is to use a minimal quantity of egg yolk in the extender.

- Chemically defined media have been shown to be effective for the cryopreservation of small ruminant sperm. They offer the advantage of not containing any additional animal products, which guarantee its biosecurity for international movement of semen.
- Additional improvement in preservation of semen has been achieved by addition of antioxidants.
- Small ruminant sperm are cryopreserved in either 0.25 mL or 0.5 mL straws and rarely in a dry pellet form. Semen handling and thawing procedures (time and temperature) are critical for viability.

TIMING OF INSEMINATION

- Natural estrus AI is performed 12 hours after detection of estrus. A second insemination is often needed 12 hours later if frozen-thawed semen is used.
- Fixed time after synchronization.
- TC3 insemination: Sheep – 55 hours (1 dose) or 50 and 60 hours (2 doses) after progesterone removal. Goats – 45 to 65 hours (1 dose) or 30 and 48 hours (2 doses) after progesterone removal.

Differential Diagnosis

- Artificial 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.
- Intravaginal—At least 200 million sperm are deposited into the cervical canal as far as the AI gun can advance.
- TC3—Between 50 and 100 million spermatozoa are required. TC3 is used more in goats as the cervix is more easily catheterized. In sheep, TC3 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 TC3 in sheep; these include the use of special cradles for restraint, and the use of flexible AI guns.
- Laparoscopic—Semen is injected directly into the uterus via laparoscopic portals. 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.

Differential Diagnosis

- Natural estrus AI is performed 12 hours after detection of estrus. A second insemination is often needed 12 hours later if frozen-thawed semen is used.
- Fixed time after synchronization.
- TC3 insemination: Sheep – 55 hours (1 dose) or 50 and 60 hours (2 doses) after progesterone removal. Goats – 45 to 65 hours (1 dose) or 30 and 48 hours (2 doses) after progesterone removal.
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

• Estrus 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 uterine horn is stabilized with the needle of the insemination gun and semen is deposited in the lumen.
• Skin incisions are usually closed with staples or absorbable sutures.

MEDICATIONS

DRUGS OF CHOICE

• Sedation and anesthetic xylazine and ketamine.
• Administration of antibiotics and anti-inflammatory agents 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.
• Pregnancy diagnosis should be performed after an AI program.

PREVENTION

N/A

MICROBIAL INFECTIONS

• None

ASSOCIATED CONDITIONS

N/A

AGE-RELATED FACTORS

TCI is more difficult in young maiden females.

ZOOONOTIC 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, Lentinus infection, paste des petits ruminants, Salmonella enteric serotype abortus, sheep 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.
Aspiration Pneumonia

Aspiration pneumonia arises from the inhalation or accidental administration of liquids, pastes, gels, or foreign bodies (plant debris, dirt) which can result in inflammatory, granulomatous or granulomatosus pneumonia, or in the case of oil aspiration, lipid or lipoid pneumonia. Some substances directly insult the respiratory tissues, while others may induce vigorous inflammatory responses associated with nondegradable foreign material. Secondary bacterial infection is a common sequela.

INCIDENCE/PREVALENCE
Uncommon

GEOGRAPHIC 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 invasion 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 cria may suffer aspiration from accidental orotradical intubation 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 aortic arch defects; 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; toxicities (ingestion of lead, crude oil, fuel oil, natural gas condensate, rhododendron); 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 gastrostomically by unskilled personnel.
* Heavy sedation or general anesthesia.
* Oropharyngeal and esophageal disorders.
* Submersion dipping of livestock.
* Exposure to poorly cured silage (rhododendron); and from oral medication administration or severe hypocalcemia (lactating cattle).

DIFFERENTIAL DIAGNOSES
* Acute bronchopneumonia due to infectious agents or causes other than aspiration.
* Systemic sepsis, particularly in neonates.
* Chronic inflammatory lung disease.

CBC/BIOCHEMISTRY/URINALYSIS
* Complete blood count may demonstrate leukocytosis or leukopenia with left shift, elevated total plasma protein, and hyperfibrinogenemia.
* Serum chemistry may demonstrate hyperglobulinemia and azotemia, and/or specific electrolyte abnormalities such as hypocalcemia.

OTHER LABORATORY TESTS
N/A

IMAGING
* Radiographs typically show alveolar-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.
* Pharyngeal abscession or trauma, and esophageal dilation, intussusception or obstruction may be evident on radiographs (contrast enhancement can be performed if indicated).

DRUGS OF CHOICE
* Broad-spectrum antibiotic therapy is indicated to cover Gram-positive and Gram-negative bacterial agents and should start as soon as possible after the aspiration event is recognized, typically regardless of whether clinical signs exist.
* Steroidal and/or nonsteroidal anti-inflammatory agents can be utilized to control shock and inflammation.

SURGICAL CONSIDERATIONS AND TECHNIQUES
N/A

CONTRAINDICATIONS
Oral administration of medications during treatment is likely contraindicated if negative pressure in pharyngeal and esophageal function are present.
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.

PREVENTION
• 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
• Calf Diphtheria/Necrotic Stomatitis
• Enzootic Pneumonia of Calves
• Respiratory Disease: Bovine
• Respiratory Disease: Camelids
• Respiratory Disease: Small Ruminant

Suggested Reading

Author
Jeff Lakritz

Consulting Editor
Erica C. McKenzie
Ruminant, Second Edition

Atypical Interstitial Pneumonia

OVERVIEW

Atypical interstitial pneumonia (AIP) is a loosely defined term that covers a variety of respiratory disorders with different etiologies. These disorders typically present with acute respiratory distress and are characterized by the microscopic findings of pulmonary congestion or edema, hyaline membrane formation, epithelial hyperplasia, and interstitial emphysema.

CAUSES AND RISK FACTORS

- Intoxication with 3-MI, 4-IP, and perilla ketone may appear clinically similar to one another but can usually be readily separated on review of management factors.
- Infectious respiratory diseases (particularly bovine respiratory syncytial virus).
- Hypersensitivity pneumonitis of confined adult cattle (extrinsic allergic alveolitis).
- Verminous pneumonia (Dictyocaulus viviparus).

Pathogenesis

Ingestion of moldy sweet potatoes by cattle infected with the fungus Fusarium solani can result in comparable lung injury to 3-MI and 4-IP toxicity. The tall, green plants are found along the edge of wooded areas in pastures and grow well in irrigated or fertilized pastures in fall. Ingestion of sweet potatoes by cattle is most likely to occur in late summer when other plants are dry. Intoxication commonly occurs in drought periods when other plants are dry. Consumption of moldy sweet potatoes by cattle infected with the fungus Fusarium solani can result in comparable lung injury to 3-MI and 4-IP toxicity.

AIP related to 3-MI toxicity has been reported in the United Kingdom, Canada, and the western United States. Moldy sweet potatoes and perilla ketone toxicity occur in southeastern USA. Feeding of moldy sweet potatoes is not uncommon in the USA, Canada and other countries can develop AIP of unknown etiology.

SYSTEMS AFFECTED

Respiratory

PHYSIOLOGY

- 3-MI toxicity results from ruminal conversion of L-tryptophan to 3-MI which is absorbed from the rumen and further metabolized in the lung, resulting in bronchial, alveolar epithelial, and endothelial damage with pulmonary edema, hyaline membrane formation, alveolar epithelial hyperplasia, and interstitial emphysema resulting in hypoxemia and distress. Most often this arises after movement of cattle from sparse, dry feed, to lush green pastures without significant time for acclimation or feed additives provided to prevent AIP.
- 4-IP toxicity arises with the formation of furanosteroid toxins by sweet potatoes infected with the fungus Fusarium solani. Ingestion of moldy sweet potatoes by cattle allows these compounds to be absorbed from the rumen and converted in the lungs to toxic metabolites that produce bronchial, alveolar epithelial, and endothelial injury by irreversible binding to cellular proteins.
- Perilla ketone toxicity occurs in cattle grazing on sparsely pastured in late summer in the southeastern USA (Perilla frutescens) and New Zealand (Perilla maculata). The tall, green plants are found along the edge of wooded areas in pastures and grow well in late fall when other plants are dry. Intoxication commonly occurs in drought periods when other plants are dry. Consumption of moldy sweet potatoes by cattle infected with the fungus Fusarium solani can result 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.

HISTORICAL FINDINGS

- Management factors relevant to these disorders include feeding of moldy sweet potatoes, access to toxic plants, exposure to noxious gases, or finishing stages in a feedlot environment. Pasture-related AIP develops within 2 weeks of sudden movement to a variety of lush pastures.

SIGUALMENT

- Adult cattle are most susceptible, typically lesions exist within 2 years of age.
- Nursing calves are generally not affected and yearlings are less susceptible.
- Feedlot cattle, particularly heifers, nearing the end of their feeding period are predisposed to AIP.

PHYSICAL EXAMINATION FINDINGS

- Sudden onset of severe respiratory dyspnea with open mouth breathing, pyrexia, extension of the head and neck, distress, and anxiety.
- Quiet lung sounds are noted on auscultation; coughing is uncommon.
- Collapse and sudden death can occur with irritation.
- Subcutaneous emphysema may occur.

GENETICS

- No breed predisposition.
- Heifers are 2-3 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 (1-2 years).
- Access to toxic plants in times of limited feed availability.
- Consumption of moldy sweet potatoes.

IMAGING

Not typically indicated.

OTHER DIAGNOSTIC PROCEDURES

Necropsy

PATHOLOGIC FINDINGS

- Typically lesions are confined to the respiratory system. The lungs are heavy, wet and rubbery, and do not float. The lungs may fail to collapse and maintain rib impressions after the thorax is opened. Perichondral hemorrhages may be evident in the upper respiratory tract, with foamy fluid in the large airways. Incriminating feedstuffs (Perilla maculata, moldy sweet potatoes) may be present in the rumen.
- Microscopic pulmonary lesions include congestion, edema, hyaline membranes, interstitial emphysema, and proliferation of alveolar epithelial cells.

TREATMENT

No specific antibacterial therapy. Largely limited to preventing further exposure to offending pasture, feed, or toxins, and avoiding stress or exertion that exacerbates respiratory distress.

SURGICAL CONSIDERATIONS AND TECHNIQUES

N/A

MEDICATIONS

DRUGS OF CHOICE

- Treatment should be considered carefully and performed with caution due to associated stress.
Atypical Interstitial Pneumonia (Continued)

- Furosemide (1 mg/kg IM or IV, q24h or q12h).
- Flunixin meglumine (1.1–2.2 mg/kg IV, q24h or divided q12h).
- Dexamethasone (0.05 to 0.2 mg/kg IM or IV, once or twice).
- Antibiotics may be indicated to prevent secondary bacterial pneumonia.

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 (commensurate 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 curtailing and windowing pasture before running 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.

MISCELLANEOUS ASSOCIATED CONDITIONS
Secondary bacterial bronchopneumonia
Viral respiratory infections

AGE-RELATED FACTORS
Young animals are resistant.

ZOONOTIC 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 emphysema
- Pulmonary adenomatosis
- Acute respiratory distress syndrome

ABBREVIATIONS
- AIP = atypical interstitial pneumonia
- 3-MI = 3-methylindole
- 4-IP = 4-ipomeanol

SEE ALSO
Respiratory Disease: Bovine

Suggested Reading

Author Jeff Lakritz
Consulting Editor Erica C. McKenzie
AVOCADO TOXICOSIS

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, infrquent 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:
  - 30 g of fresh leaves/bwt (kg) in lactating goats
  - 25 g fresh leaves/bwt (kg) for 5 days in sheep (severe signs)
  - 5.5 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

Author
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