This presentation will review some unique and challenging cases. These cases include the following: a case of albendazole toxicity in alpacas, spastic paresis in a pygmy goat, a few cases of severe preputial stricture in bulls, and other cases of reproductive failure in bulls.

**Albendazole toxicity in alpacas**
Three crias presented for fevers of 24 to 48 hours duration. The crias were a 2 month old female, a 6 months old male, and a 7 month old male. The fevers were ~105-107°F. The owner administered flunixin meglumine and oxytetracycline prior to presentation and had a history of lethargy and diarrhea. Physical examinations of the three crias revealed that the crias were depressed with harsh lungs sounds; all crias were febrile and had diarrhea. Diagnostics performed included complete blood counts (CBC), chemistry profile, fibrinogen, fecal examinations, BVDV testing, and +/- fecal cultures. The female cria was positive for tapeworms while the 2 male crias were negative for parasites. All crias were negative for BVDV via PCR from buffy coat, and fecal cultures were negative, as well. Complete blood counts revealed severe leukopenia, specifically neutropenia, in all crias with WBC counts of 4200, 2030, and 180; serial CBCs showed a regenerative response. Treatments for the crias consisted of florfenicol antibiotic (n=3), praziquantel anthelmintic (n=1), IV fluids (n=1), flunixin meglumine (n=2), and Filgrastim (n=1). Filgrastim is a human granulocyte colony-stimulating factor (G-CSF) that acts on hematopoietic cells to stimulate proliferation and differentiation. In the one cria that received Filgrastim, the WBC count increased from 2030 to 6910 following 2 days of treatment (one vial = $240). One animal died soon after presentation, and the remaining 2 animals were discharged with no explanation for the severe neutropenia. After speaking to the owner (for the fourth time), he “remembered” giving albendazole and numerous other anthelmintics to his young crias; albendazole was given >5 times the label dose for at least 5 days in most cases. Albendazole toxicity causes bone marrow hypoplasia with 9 previous cases reported in alpacas (Gruntman, 2006). Three to four months following administration of the toxic doses of albendazole, the affected alpacas began to “blow their fiber” with large foci of alopecia.

**Spastic paresis in a pygmy goat**
Spastic paresis is rare, but has been reported in 3 pygmy goats between the ages of 1-2 years (Baker et al, 1989) and in Czechoslovakian in a Saanen goat in 1973. Clinical diagnosis is based on physical examination. Successful treatment of spastic paresis in these goats included tibial neurectomy (n=4) and desafferentation of the dorsal spinal roots (n=1). The goat that presented underwent bilateral, tibial neurectomy. Tibial neurectomy was performed by dissecting between both parts of the biceps femoris m. and identifying the tibial nerve. Successful identification of the tibial nerve is confirmed with electrostimulation of the nerve and appropriate muscle stimulation. Once the nerve has been accurately identified, the nerve is transected. Within 24 hours of surgery, the goat began walking normally and one leg and much improved on the second leg. The owner reported a normal gait in the goat 3 months post-operatively.

**Severe preputial stricture in bulls: an interesting repair**
A 10 year old Brahman bull presented for a history of preputial injury which had been treated conservatively by the rDVM. The owner and rDVM became concerned about the bull when he noticed that the bull was having difficulty urinating. On presenation, the bulls had a preputial swelling approximately 6 inches proximal to the preputial orifice. A stricture was palpated inside the preputial orifice, and necrotic tissue was removed which allowed the bull to urinate. Owner wanted to do everything possible to save the bull so a resection and anastomosis of the prepuce was performed. Seven days post-operatively, another stricture was detected at the surgical site. Four weeks later, and second resection and anastomosis of the prepuce was performed, and four days later, the prepuce began to stricture down yet again. So, a plastic tube was inserted into the preputial cavity to help prevent further stricture formation. The plastic tube was maintained within the preputial cavity for fifty-five. Once the tube was removed from the preputial cavity, the prepuce continued to stricture. Therefore five days later, surgery was performed to create a preputial stoma. A two inch stoma was created between the ventral prepuce and skin of the sheath to create a marsupialization from the prepuce to the skin. A penrose drain was sutured to the penis and exited through the stoma. The bull was discharged with 60 days of sexual rest. Following this time, the owner exposed the bull to a cow and saw the bull breed the cow. The cow was only exposed to this bull, and the rDVM confirmed that the cow was pregnant; the Brahman bull mentioned above with a calf on ground by natural service, and a Santa Gertrudis bull that has had semen collected through his stoma.
Fetal mummification in a Brahman cow
A 5 year old Brahman cow that was primarily used as an embryo donor presented for a possible fetal mummification. A 7 day embryo was transferred on May 24th. She was confirmed pregnant approximately 4 weeks later on June 20th with an estimated calving date of March 3rd. Upon passing her due date, the cow was palpated by the rDVM and diagnosed with a possible mummified fetus (~7 month fetus). Upon presentation, the physical examination was normal except for the presence of a presumed fetal mummy of approximately 6-7 months of age. The fetus was difficult to reach via transrectal palpation. Due to the potential value of the fetus, additional diagnostic tests were performed to confirm the diagnosis of fetal mummification. These additional tests included the following: transabdominal ultrasonography, testing for pregnancy specific protein B with the BioPRYN® blood test, and fetal electrocardiogram. The fetal echocardiogram was performed by directing the leads across the cow (negative lead at mid-level jugular groove, positive lead at inguinal region between stifle and abdomen). This technique would allow for detection of both the dam and the fetus’ heart rate and rhythm at the same time. Based on ECG, ultrasound, and eventually a BioPRYN® test, the cow was confirmed to be pregnant with a fetal mummy. Based on the size of the fetal mummy, luteolytic drugs and colpotomy were ruled out as possible treatment options. Because of the value of the cow, the owners elected for surgical removal of the fetal mummy with the cow under general anesthesia. References available upon request.
The use of antimicrobials has been a conventional therapy in treatment of uterine infections in cattle. However, the use of antibiotics has not been without controversy. Debate continues regarding antimicrobial efficacy, effects on future fertility, risk for bacterial resistance and residues. The proper use of antimicrobials to treat uterine infections must first begin with an appropriate diagnosis and thorough understanding of the immunology of the uterus, the pathophysiology of uterine infections, and the properties of the various antimicrobial agents that may be used therapeutically.

Intrauterine therapy

A variety of antibiotics and antiseptics have been infused into the uterus of cows to treat postpartum infections. Intrauterine antimicrobials are used in order to achieve high concentrations at the site of infection but are usually unable to penetrate any deeper than the endometrium. The intrauterine use of antimicrobial agents is controversial as some have found intrauterine treatment to be beneficial while others have found these agents to have no effect or a detrimental effect. The bovine uterus is an anaerobic environment. Thus, antibiotics that are chosen for intrauterine infusion must be active in the absence of oxygen. Additionally, most antibiotics depress the activity of uterine neutrophils and interfere with uterine defense mechanisms. Thus, one must carefully evaluate the evidence regarding intrauterine antimicrobial use and carefully consider both the advantages and disadvantages associated with therapy.

Historically, intrauterine use of antimicrobials has been a common therapy for treatment of uterine infections. Antimicrobials that have been reportedly used for these infections include tetracycline, penicillin, cephapirin, chloramphenicol, Lugol’s iodine, gentamycin, spectinomycin, sulfonamides, nitrofuransone, povidone iodine solution, urea, and chlorhexidine. Although, most of these compounds are not approved for intrauterine use and have no published withdrawal times. There are also reports that intrauterine infusion of antibiotics causing drug residues in milk. In addition, regulatory guidelines must be adhered to in cases of extralabel use of antimicrobials in food animals. Intrauterine therapy is considered an extralabel use, and thus may be prohibited for many antibiotics, particularly in the United States.

The organisms that cause most postpartum infections are usually sensitive to penicillin. However, bacterial contaminants present within the uterus during the first several weeks postpartum produce penicillinase which makes penicillin useless if used locally in the early (less than 30 days) postpartum period. By 30 days postpartum, the contaminant bacteria are usually eliminated and intrauterine treatment with penicillin is more likely to be effective. Other factors may also affect the efficacy of intrauterine antibiotic therapy. Uterine lochia present during uterine infections contains organic fluids and debris that can render certain antibiotics, such as sulfonamides, ineffective.

More recently, oxytetracycline has been the antimicrobial that is commonly used for intrauterine therapy. However, one study indicated that most isolates of *A. pyogenes* are resistant to oxytetracycline. This study also showed that large doses of intrauterine oxytetracycline did not affect the frequency of isolation of *A. pyogenes*. In addition, oxytetracycline as well as Lugol’s iodine are quite irritating and are reported to cause coagulation necrosis of the endometrium. Although some studies indicate an improvement in reproductive performance with the use of intrauterine oxytetracycline, it has been speculated that this improvement may be due to local prostaglandin production due to chemical irritation of the endometrium.

In general, intrauterine infusion of antimicrobials has generally failed to show any increase in reproductive performance. Although, two large field studies evaluated the use of cephapirin benzoate in cows with clinical endometritis and reported some improvement in reproductive performance. However, other studies indicate no improvement in reproductive performance when evaluating intrauterine administration of cephapirin benzoate. The appropriate use of intrauterine antibiotics to treat uterine infections still remains controversial as only a limited number of studies indicate the efficacious use of intrauterine antibiotics.

Intrauterine antiseptics

Numerous antiseptics have been used to flush and lavage the postpartum bovine uterus with iodine and chlorhexidine solutions being most commonly used. Many of these solutions are quite irritating to the endometrium and are thought to stimulate endogenous prostaglandin release. One study showed that the incidence of retained fetal membranes and endometritis was reduced in cows that received 500 mL of 2% Lugol’s iodine immediately after calving and again 6 hours later. However, this study did not evaluate the future reproductive performance of these treated cows. Another study evaluated the use of 50 to 100 mL of 2% povidone iodine solution in the uterus one month postpartum and found that the reproductive performance of normal cows was not improved and that the treatment was detrimental to the fertility of cows with endometritis.
**Systemic antibiotic therapy**

Cattle with metritis often suffer from moderate to severe illness. These cattle are often septic and present with fever, depression, and anorexia. A variety of antibiotics have been recommended for parenteral use in cattle suffering from uterine infections. Penicillin or one of the synthetic penicillin analogues and ceftiofur are two of the most common antibiotics used systemically in cattle suffering from metritis. Systemic use of oxytetracyline may not be efficacious because of the difficulty in achieving the minimal inhibitory concentration (MIC) required for *A. pyogenes* in the uterine lumen. However, one study reported clinical improvement of cattle suffering from metritis with the use of tetracycline at 10mg/kg.

Ceftiofur is a third generation cephalosporin that has broad-spectrum activity against gram negative and gram positive bacteria. Ceftiofur (when administered parenterally) is reported to reach all layers of the uterus without causing violative residues in milk. Ceftiofur is approved in the United States for systemic administration to lactating cows affected with metritis. A subcutaneous dose of ceftiofur at 1mg/kg in post-partum cows results in a concentration of ceftiofur and its active metabolites in plasma, uterine tissues, and lochia at a higher MIC than required for most of the common pathogens involved in metritis. One study demonstrated that ceftiofur administered at 2.2mg/kg daily for 5 days was effective in treating cows with metritis. Another study supported these findings and showed ceftiofur administered at 2.2 mg/kg once daily for 5 days is as effective for treating metritis as procaine penicillin G or procaine penicillin G with intrauterine infusion of oxytetracycline.

Because of the reported lack of efficacy and potential detrimental effects of future fertility, intrauterine infusion of antibiotics is not a favored treatment for most cases of metritis. Certain systemic antibiotics have demonstrated their effectiveness at treating uterine infections in cattle. Thus, most cases of metritis, especially cows that are toxic, should be treated with systemic antibiotics such as penicillin or ceftiofur.

**Conclusion**

There are no antibiotics currently approved for intrauterine administration. Intrauterine infusion of antibiotics leads to contamination in milk and tissues for which appropriate withdrawal times have not been ascertained. In addition, the assays used on farm to detect antibiotics in milk may not be accurate. Although some studies indicate a positive response to therapy with the use of intrauterine antimicrobials, most studies do not show an improvement in reproductive performance or clinical signs of disease when comparing intrauterine antimicrobial therapy and systemic antibiotic therapy. This information, in conjunction with concerns regarding uterine or endometrial damage and withdrawal times following the use intrauterine antimicrobials, suggests systemic antibiotic therapy as the best treatment for many cases of cows with uterine infections.

References available upon request.
Bovine Trichomoniasis
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Bovine trichomoniasis is a sexually transmitted disease caused by the extracellular protozoa *Tritrichomonas foetus*, an obligate parasite of the reproductive tract of the cow and the folds on the mucosal surfaces of the bull’s penis and prepuce. Infected bulls are often asymptomatic carriers of *T. foetus*. However, these infected bulls are capable of transmitting the organism to a cow during coitus. Infections in cows cause endometritis, cervicitis, vaginitis which may result in early embryonic death, abortion, pyometra, fetal maceration, or infertility. The major economic losses associated with *T. foetus* are due to: 1) reduced calf crop due to early embryonic loss or abortion, 2) reduced weaning weight due to delayed conception, and 3) culling and replacement of infected cattle. Due to the inability to use efficacious drugs, such as the nitromidazoles, for control and prevention of *T. foetus* infections in food animals, most control efforts have targeted identification and elimination of positive bulls, systemic immunization of cows and bulls, and management strategies to prevent introduction of the organism into the herd.

Pathogenesis in the female
Life cycle
The life cycle of *T. foetus* is thought involve two forms 1) a tear-shaped trophozoite form and 2) a pseudocyst form. The trophozoite is 10-25μm long and possesses three posterior flagella, one anterior flagellum and an undulating membrane. Trophozoite multiply asexually through binary fission. Pseudocysts usually appear as a result of unfavorable conditions; although, a small percentage of pseudocysts exist under normal conditions. Pseudocysts occur when *T. foetus* trophozoites round up and internalize their flagella in response to assorted stimuli. The pseudocyst form lacks a protective cyst wall and does not represent a true cyst form. Trophozoites of *T. foetus* are transmitted between cows and bulls during coitus and remain in the genito-urinary tract where they multiply by longitudinal binary fission. Under stressful conditions trophozoites will internalize their flagella and replication of the nuclei and other cellular structures will occur, resulting in a multinucleated pseudocyst form. When conditions become desirable once more, mononucleate trophozoites will bud from the pseudocyst. In bulls, infections are usually chronic and asymptomatic and often persist for the life of the animal. Infected cows will initially experience vaginitis which may or may not resolve spontaneously. In some cases, endometritis can occur resulting in complete sterility. Tritrichomonas infections may also result in fetal loss during pregnancy.

Transmission
Cows become infected with *T. foetus* primarily through coital exposure with an infected bull. Subsequently, a mild vaginitis occurs that may go undetected. The organism gains entry into the uterine lumen via the cervix during estrus. Colonization of the entire reproductive tract with *T. foetus* occurs within 1 to 2 weeks. Although, contaminated semen or contaminated insemination equipment may also be minor sources of infection. Penetration of the vagina is seemingly necessary because swabbing the vulvar area with high numbers of organisms does not result in vaginal or uterine infection. Infected cows conceive but infection causes endometritis, cervicitis, or vaginitis which results in death of the conceptus within the first half of gestation, abortion, pyometra, fetal maceration, or infertility. These infected cows usually remain infertile for a period of 2 to 6 months. In heifers, the duration of infection is reported to be as short as 95 days or as long as 22 months. *Tritrichomonas foetus* has been detected in the reproductive tract for 13 to 28 weeks after experimental infection in heifers.

Consequences of infection
*T. foetus* organisms arrive in the female reproductive tract concurrently with spermatozoa. However in most cases, fertilization occurs in spite of the presence of the pathogen. In vitro studies have demonstrated that fertilization and early embryonic development to the hatching stage (8-10 days) are not significantly affected by simultaneous culture with *T. foetus*. Conceptus deaths most commonly occur between 50-70 days of gestation. Therefore, the majority of pregnancy loss is during the fetal period (>42 days of gestation). Although unusual, occasional abortions can occur of fetuses greater than four months of gestation. Most producers do not recognize a problem in the early breeding season as conception occurs normally. The conceptus in most infected cows typically survives long enough to release sufficient interferon tau to prevent the prostaglandin F2α-mediated lysis of the corpus luteum. Fetal death in infected cows occurs between 7 to 10 weeks of gestation. Death of the conceptus during the early stages of pregnancy results in a prolonged interestrus interval. Due to abortions and subsequent immunity, the distribution of pregnancies is unusually skewed with a higher proportion of pregnancies conceived towards the end of the breeding season. Although in many progressively managed herds with a limited breeding season, the bulls may no longer be available by the time the cow aborts and clears the infection. Therefore, *T. foetus* infection in a herd may go unnoticed until the time of pregnancy diagnosis when a high percentage of females are diagnosed not pregnant. Pyometra, along with abortions, may be the first physical signs of *T. foetus* infection in a herd, but are thought to occur in less than 5% of infected cows. Pyometra results as the corpus luteum of pregnancy is maintained with a large purulent response which may cause damage to the uterine endometrium.
Most infected cows will clear the organism and develop short-lived immunity of 6 months to one year. However, carrier cows do occur and are capable of spreading the protozoa. In the case of carrier cows, a very small percentage of cows (<1%) in infected herds have been shown to remain infected throughout pregnancy and into the following breeding season. Thus, the carrier cow has the potential to be quite devastating to control efforts and emphasizes that control programs must focus on the entire herd, not just the bull. Pathologic changes have been reported in several late-term, *T. foetus* aborted fetuses. The placentas had focal or diffuse invasion of the chorionic stroma by *T. foetus* as seen on hematoxylin and eosin (HE) stained sections of placentas. There was also evidence of a moderate inflammatory cell infiltrate comprised mostly of mononuclear cells. Six of eleven fetuses that were examined had bronchopneumonia with identifiable trichomonads in the airways. Another examination of late term abortions associated with *T. foetus* described a necrotizing enteritis and pyogranulomatous bronchopneumonia with tissue invasion by trichomonads. The exact mechanism that leads to the death of the conceptus is not fully understood. Although, cytotoxic and hemolytic effects by *T. foetus* on mammalian cells have been described.

The preputial cavity of the bull provides an ideal environment for *T. foetus* as the organism localizes in the preputial smegma of the epithelium of the bull’s penis and prepuce. The organism does not penetrate the epithelium and does not cause any observable gross pathology or affect semen quality or libido. Histological changes are subtle at first with an increase in the number of neutrophils in the nonkeratinized, stratified squamous epithelium of the glans penis and preputial epithelium followed by an infiltration of lymphocytes and plasma cells penetrating into the intraepithelial area which coalesce in the subepithelium to form lymphoid nodules. The duration of infection with *T. foetus* for bulls is not clearly understood. There are two theories regarding this debate: 1) transient infection and 2) chronic carrier state. Bulls with the chronic carrier infection of *T. foetus* rarely clear the infection regardless of time. The pathophysiology of infection regarding the carrier state in mature bulls is not fully understood. *T. foetus* infections in bulls less than 3-4 years of age are more likely to have a transient infection. Younger bulls may not efficiently transmit the organism to a noninfected cow unless the sexual contact occurs within minutes to days of breeding an infected cow. Thus, transmission of *T. foetus* by a young bull is thought to be more passive, mechanical transmission as compared to transmission in older, chronically infected bulls.

Nonetheless, any bull exposed to a *T. foetus* infected cow as a result of natural breeding is capable of becoming chronically infected, regardless of age.

**Immunity**

In the female, *T. foetus* induces inflammation of the mucosa of the vagina, the cervix, the endometrium and the oviductal mucosa. In the first one to two weeks post infection, neutrophils and eosinophils predominate; however, this is followed by a moderate to severe mononuclear infiltration of lymphocytes and plasma cells. Subepithelial and periglandular lymphoid nodules resembling lymphoid follicles begin to develop at almost six weeks post infection. In addition, there is also an apparent degranulation of mast cells between six to nine weeks post infection. *T. foetus* specific IgA and IgG1 antibodies are detectable in uterine and vaginal secretions by the fifth to sixth week post infection. The IgA antibodies do not kill the organisms but may be responsible for immobilization and agglutination of parasites as well as preventing adhesion of the organisms to the mucosal surfaces. The IgG1 antibodies are presumed to facilitate complement mediated lysis of the parasites as well as opsonization and enhanced phagocytosis killing by neutrophils or macrophages. Immunity following natural infection and clearance of *T. foetus* is short-lived with females becoming susceptible within a year, in time for the following breeding season. Because *T. foetus* is an extracellular pathogen, the immune response from the host is predominately humoral and the result of the short-lived immunity. The uterine mucosal inflammation that is seen with infection may allow systemically derived IgG and complement to gain access to the lumen of the uterus and, thus, clear the organism. A relative lack of IgG from the vagina or possibly blocking of IgG effects by vaginal IgA binding of organisms may help explain the carrier state that can be seen in infected herds. Although specific immunoglobulins have been detected in small amounts in preputial smegma by some researchers, there seems to be no effective acquired immunity to *T. foetus* in the mature bull.

**Diagnosis**

The comparison of diagnostic assays for detection of *T. foetus* infections has primarily focused on the bull. Collection of *T. foetus* samples from bulls involves recovering the organism from the preputial cavity of the bull. Several techniques have been described for collection of diagnostic specimens in the bull and include a dry pipette technique, a wet pipette technique a douche technique and a swab technique. While the douche method is preferred in Europe, the dry pipette technique is most commonly used in the United States. Regardless of which technique is used, it is generally recommended that bulls be given 2 weeks of sexual rest prior to sample collection in order to allow accumulation of the organism on the bull’s penis and prepuce and a greater chance of recovery.

Isolation of *T. foetus* from the female is reported to be less sensitive when compared with techniques used for bulls. In one study, the InPouch™ TF system (BioMed Diagnostics, Inc; White City, OR) was more effective than Diamond’s medium (88% versus 68% in detecting heifers that had been experimentally infected with *T. foetus*. The accuracy of prevalence in the cow most likely depends on the timing of sampling relative to exposure. The immune response in females begins to eliminate the infection within 8 to 10 weeks after exposure in unvaccinated females. Therefore, cultures from females are best performed before the infection is possibly eliminated by the immune response.
Sample handling is also crucial for accurate detection of *T. foetus*. When evaluating temperature and media type it has been found that when laboratory of field isolates were cultured in Diamond’s medium or InPouch™ TF, all cultures were positive for *T. foetus* when maintained for us to 4 days at either 22° or 37°C. However, samples maintained at 4°C or less resulted in inconsistent sensitivity. It is important to remember that time, temperature, type of isolate, and type of media all have an effect on the sensitivity of *T. foetus* culture.

Microscopic evaluation of cultured organisms is not sufficient to differentiate *T. foetus* from nonpathogenic intestinal or coprophilic trichomonads (*Pentatrichomonas hominis*, *Simplicimonas moskowitzii*, *Tetrastrichomonas* spp., etc). Therefore, several conventional and real-time polymerase chain reaction (PCR) assays have been developed for the definitive diagnosis of trichomoniasis, and this methodology has demonstrated some advantages over culture. However, accurate PCR results are directly related to the quality of the sample, which can be affected by transport condition parameters such as temperature and time of transport to the laboratory. There have been a number of issues that have limited the sensitivity of various conventional PCR assays for the detection of *T. foetus*. These problems include DNA degradation, accumulation of inhibitory compounds, sample contamination, and unexpected amplification products. One study demonstrated a decrease in sensitivity of PCR testing with samples that were stored for 5 days or more. However, PCR was in 100% agreement with culture as long as the PCR was performed within 24 hours of the sample being submitted.

A more recent study evaluated the effect of different simulated transport conditions on samples containing *T. foetus* for the diagnosis of trichomoniasis using culture and quantitative PCR (qPCR). This study demonstrated that transport temperatures of 4–20°C for 1–3 days before culture reduced or temporarily inhibited parasite replication but maintained viability. Samples tested by either culture or qPCR would have been expected to give positive results. However, diagnosis of trichomonads by both methods was negatively affected when specimens were maintained at transport temperatures of 42°C for 24 hours or more. This study emphasizes the importance of ensuring that clinical samples arrive to the diagnostic laboratory within 24–48 hours and of avoiding temperature transport conditions above 37°C in order to achieve an accurate diagnosis of *T. foetus*. The effects of high incubation temperatures on culture and real-time PCR for *T. foetus* have also been evaluated following inoculation into the InPouch™ TF system. This study showed that *T. foetus* was detectable at microscopically in inoculated pouches incubated at 37°C regardless of exposure time (1, 3, 6, and 24 hours), whereas those samples incubated at 46.1°C detected *T. foetus* only after 1 and 3 hours of incubation. *T. foetus* was detected in samples incubated at 54.4°C after only 1 hour. Testing using real-time PCR for all inoculated media samples (37°C, 46.1°C, and 54.4°C at 1, 3, 6 and 24 hours) produced positive results for all inoculated media samples. This study suggests that samples collected for culture alone should be protected from high temperatures.

**Prevention and control**

One complicating factor with bovine trichomoniasis in the United States is the lack of effective treatments with U.S. Food and Drug Administration approval. Historically, the most successful treatment for bulls with trichomoniasis was systemic treatment with nitromidazole derivatives. Currently, the use of nitromidazole derivatives is illegal in food-producing animals in the U.S., and no effective alternative treatments are available. The lack of effective, approved therapies for bovine trichomoniasis emphasizes the need for appropriate preventive and control measures. Prevention of trichomoniasis includes the following recommendations: 1) avoid movement of animals (co-grazing, leasing of bulls, good fences); 2) utilize artificial insemination, if possible; 3) use a defined breeding season and calv all non-pregnant females after the breeding season; 4) purchase virgin bulls and heifers as replacements; 5) test all bulls for *T. foetus* prior to introduction into the herd and maintain a young population of bulls; and 6) breed purchased cows and heifers in a separate herd.

Once *T. foetus* has been confirmed in a herd, there are additional measures that should be considered in order to “clean up” the herd. These measures include 1) testing and culling all infected bulls and purchasing *T. foetus* negative bulls; 2) intense management of bulls so that smaller breeding units are used and bulls are bred to the same cattle until trichomoniasis is under control; 3) create high and low risk herds; and 4) vaccinate all herd females with an approved *T. foetus* vaccine. Vaccination is an important aspect of any control program as it has been shown to reduce pregnancy wastage associated with *T. foetus* infection in cattle herds. Currently, TrichGuard® (Boehringer Ingelheim Vetmedica, Inc.) is the only commercially available vaccine licensed by the USDA for the control of trichomoniasis in the United States. TrichGuard® is a proprietary vaccine that is a Freund adjuvant killed *T. foetus*-derived vaccine that requires two doses subcutaneous injections administered 2 to 4 weeks apart with the last injection to be given 4 weeks prior to the breeding season. One study compared pregnancy and calving rates between beef heifers vaccinated with TrichGuard® and control heifers after heifers were exposed to *T. foetus* infected bulls and intravaginally inoculated with a large number (10 million) of *T. foetus* organisms. At calving twice as many vaccinated heifers calved when compared to control heifers (61% versus 31%). Thus, the vaccine appeared to offer at least some protection against *T. foetus*. More recent studies have confirmed these findings, as well. In addition, Palomares, et al. concluded that vaccination of heifers with TrichGuard® significantly increased the levels of IgG antibodies to the *T. foetus* surface antigen in serum, vaginal secretions, and uterine fluid; these antibody levels remained elevated through days 43, 75, and 182, respectively.

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Conclusion

Trichomoniasis can be an economically devastating infection in cattle herd with losses due to reduced calf crop due to early embryonic loss or abortion, reduced weaning weight due to delayed conception, and culling and replacement of infected cattle. Carrier females and concerns with diagnostic sampling and testing have made the control of trichomoniasis in cattle even more complex. Control and prevention of *T. foetus* infections in cattle must focus on identification and elimination of positive cows and bulls, systemic immunization of cows and bulls, and management strategies to prevent introduction of the organism into the herd.

References available upon request.
Managing Musculoskeletal Injuries in Cattle
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Lameness accounts for tremendous production loss in the cattle industry and has been identified as a particular concern in animal welfare. Cattle are relatively stoic animals and often do not show lameness until significant pathology is present. This discussion will explore anatomic and management relationships with common orthopedic conditions in cattle. Additionally, diagnostic and therapeutic options will be reviewed.

Stifle injuries
Stifle injuries are common in cattle and one or more structures may be involved. Of the common injuries rupture of the collateral ligament produces the least degree of lameness. Cattle with this condition are slightly lame and the injury may be easily diagnosed by watching them walk away from you. There is medial-to-lateral instability and the stifle will deviate either medial or lateral, toward the affected side when the animal is full weight-bearing. Restrain the animal and place fingers of one hand on the medial aspect of the stifle joint while abducting the lower limb. If the medial collateral ligament is torn there will be excessive joint space while the leg is abducted. Place the fingers of one hand on the lateral aspect of the stifle and adduct the lower limb to examine for excessive motion if the lateral collateral ligament is torn.

Meniscal tears cause the next most severe lameness in cattle. The most common injury is similar to other species in that the posterior horn of the medial meniscus is injured more commonly than the lateral meniscus. With acute injury there will be noticeable lameness and there may be evidence of joint effusion. The injury appears to occur more commonly in heavy muscled beef bulls than in other cattle. There may be an audible or palpable “click” during the weight bearing portion of the stride. The mass of the animal usually precludes palpation of the classical anterior drawer sign as may be detected in dogs. However, many beef cattle will tolerate flexion of the affected limb whereby the veterinarian may be able to detect excessive motion in the stifle joint and perhaps grating of bony surfaces due to loss of articular cartilage.

The third common and most severe stifle injury is rupture of the anterior cruciate ligament (ACL). This injury causes marked lameness and usually obvious joint effusion. The animal is very reluctant to bear weight on the affected limb.

These injuries are discussed together as they all appreciably shorten the productive life of cattle. Animals with only collateral ligament tears develop degenerative joint disease due to joint instability and abnormal wear of joint surfaces. Animals with meniscal tears do likewise with the added risk of suffering cruciate ligament tears due to the atrophy of leg muscle that frequently rapidly accompanies this injury and more severe loss of stability of the stifle joint. Animals with cruciate ligament tears suffer severe joint instability, rapid muscle atrophy and frequently quickly suffer meniscal tearing and loss of articular cartilage.

Therapy for any of the above conditions consists of confining the animal to a stall or small paddock that is level and free of mud for 6 – 8 weeks. Bulls with anterior cruciate ruptures should not be used for breeding for a minimum of 6 months. Animals with this injury usually do not return to soundness and have permanent muscle atrophy on the injured limb. Analgesics are not recommended during the acute phase of the injury as animals so treated may use the limb excessively and sustain additional trauma to the joint. However, anti-inflammatory agents may prove beneficial after a few months convalescence to assist a bull through a breeding season.

Alternatively, application of a Walker Splint on the affected limb may improve longevity in bulls with ACL ruptures. This device immobilizes the limb for 6 weeks preventing motion and additional soft-tissue damage in the joint while simultaneously allowing fibrosis of the joint capsule. Negative effects of the splint are the additional expense incurred and the degree of pressure necrosis in the flank inherent with this type splint. Following removing the splint the bull should be confined to a stall for an additional 2 – 4 weeks as the bull regains muscle tone on the immobilized leg. He should not be used for breeding for a minimum of 6 months from the original injury.

Emergency treatment & first aid
A thorough physical examination should be conducted on all animals suspected of having a fracture prior to the decision for treatment. However, the patient first must be made safe from continued trauma. Often, injured cattle are recumbent when examined. The animal should be allowed to remain recumbent until the physical examination has been conducted and an initial fracture assessment done. Adequate colostrum ingestion by newborn calves is critical to pre-operative preparation of the patient and success of the procedure. If colostrum ingestion is unknown, serum IgG should be determined or total protein measured. Calves that are well hydrated and have a serum protein of less than 5.5 g/dl should be considered to have poor colostral antibody transfer and receive a plasma transfusion before attempting fracture repair.

Temporary stabilization of limb fractures may be performed prior to moving the animal or attempting to get the animal to stand. As a general rule, fractures below the level of the mid-radius or mid-tibia may be temporarily stabilized with splints or casts. In my experience, field stabilization of fractures proximal to this level should not be attempted. These efforts often result in the creation of a
“fulcrum effect” at the fracture site and result in increased soft tissue trauma, damage to neurovascular structures, or compounding of the fracture. Cattle with these fractures should be carefully loaded into the trailer and allowed time to lie down before beginning transport.

Two splints or a cast may be used for temporary stabilization of the fracture. Two boards or pieces of PVC pipe that is cut in half and placed at 90° to each other (i.e. caudal and lateral aspect) create a stable external coaptation. A padded bandage is placed on the limb, splints and positioned and elastic tape applied firmly. The injury should be centered within the coaptation with as much support proximal and distal to the injury as possible. All external coaptation devices should extend to the ground. Injuries that occur distal to the carpus or hock should have splints placed to the level of the proximal radius or tibia. For injuries proximal to the carpus or hock and distal to the midradius or midtibia, the lateral splint should extend to the level of the proximal scapula or pelvis.

Treatments

Walking block
Because cattle have two weight-bearing digits, a cow may stand one digit during convalescence of the opposite digit (phalangeal fracture). A wooden or rubber block can be applied to the sole of the healthy digit. A walking block is most suitable for management of P1, P2, and P3 fractures of a single digit. These animals should be confined to a small pen or paddock for 6 to 8 weeks while the fracture heals. If the block remains on for 6 weeks after application, it should be removed.

Casting
Half-limb or low-limb casts can be used for immobilization of phalangeal fractures and for distal metacarpal or metatarsal physeal fractures. The cast is placed from a point immediately distal to the carpus or hock and extend to the ground with the foot included in the cast. The dewclaws and the top of the cast should be padded but only stockinette is placed on the remainder of the limb. If thick padding is placed over the entire limb, the padding quickly becomes compressed which allows room for the limb to move within the cast and displacement of the fracture to occur. Full-limb or high limb casts are used for fractures that occur at or proximal to the midmetacarpus or metatarsus but distal to the midradius or midtibia. Full-limb casts are placed in a similar manner as half-limb casts, but the bony prominences of the accessory carpal bone, styloid process of the ulna, calcaneous, and medial and lateral maleolus of the tibia must be padded.

Physical restraint, sedation, or anesthesia can be used as deemed necessary to facilitate placement of the cast. Maintaining alignment, both cranio-caudal and lateromedial, of the limb during application is essential. Tension on the limb during casting may be achieved by placing wires through holes drilled in the hoof wall and applying tension. Tension should be placed so that the hoof is positioned in a normal to slightly flexed position. The thickness of the cast is usually based on clinical judgment. Casts that are 6 to 8 layers thick are usually adequate for calves weighing less than approximately 300 pounds. However, adult cattle may require casts as much as 12 to 16 layers thick. Casts on the hind limbs must be made thicker because of the stress concentration by the angulation of the hock. Incorporating two metal rods at 90° to each other can increase the strength of the cast for extremely large animals. A walking bar (U-shaped bar placed under the hoof and incorporated into the cast) concentrates loading forces into the cast and away from the distal limb, but the foot should always be included in the cast.

Casts may be maintained in calves for up to 6 weeks without being changed. Scheduled cast changes at 3-week intervals may be required for rapidly growing calves or for calves that become lame during convalescence. Physeal fractures usually heal within 4 weeks, but nonphyseal fractures often require 6 weeks to reach clinical union in calves. Fractures in adult cattle may heal within 8 to 10 weeks, but often require 12 to 16 weeks for clinical union to occur. Radiographic union of the fracture (defined as bone union with resolution of the fracture line) is not seen for weeks to months after clinical union (defined as sufficient bridging callus to allow weight bearing without additional support to the limb) has been reached.

Thomas splint +/- cast
Use of a Thomas splint and cast combination is appropriate for fractures distal to the elbow or stifle. The length of the splint should be measured while the animal is standing and by using the normal limb for measurements. An appropriate splint is chosen or constructed, and the patient is placed into lateral recumbency (using rope restraint, sedation, anesthesia, or a combination of the three). The fracture is reduced and a cast applied from the distal metacarpus or metatarsus to the level of the proximal radius or tibia. The splint is placed on the limb, the foot is attached to the base of the splint by drilling holes in the hoof walls and wiring the foot to the splint base, and casting tape is used to attach the cast to the splint frame. The limb cast should be firmly attached to the splint frame to prevent rotation of the limb along the splint during ambulation. The hoop of the splint must be firmly placed into the axilla or groin to allow maximal weight transference. Therefore, the hoop must be heavily padded. Cattle having a Thomas splint-cast must be assisted to stand for 3 to 5 days until they learn how to rise under their own power. Also, these patients must be checked several times daily to ensure that they have not lain down on top of the splint. Often patients are not able to rise after lying down on the splint and life-threatening rumen bloat may occur if they remain trapped for a prolonged period.

Closed versus open fractures
Overall, closed fractures without damage to the blood supply to the limb have a good to excellent prognosis for healing in cattle. The prognosis for success is less for older cattle or cattle of high body weight. Open fractures have a guarded prognosis for healing in
cattle. The success rate depends on the severity of soft tissue damage, the bone affected, the age of the patient, the duration and degree of contamination of the wound, and the economic limitations placed on fracture management. Prolonged antibiotic therapy is indicated, and open wound management is preferable to enclosing the wound within a cast. Mature cattle are better able to overcome bone infection associated with open fractures than young calves. Often, mature cattle having an open metacarpal fracture are able to heal and return to productivity after thorough cleaning of the wound, administration of antibiotics, and application of a full limb cast. However, young calves with similar injury are prone to septic non-union or delayed union.

**Treatment and prognosis for specific fractures**

**Pelvis**

Fractures of the ileum or sacroiliac junction are the most common pelvic fracture in cattle. These injuries occur because of falls during mounting or on slippery flooring. Fractures of the ileum or sacroiliac junction respond well to stall confinement. Occasionally, ileum fractures become open, with bone projecting through the skin. Infection rapidly becomes established and bone sequestration occurs. Surgical removal of the fracture fragment of the ileum is indicated when sepsis or debilitating lameness is present. Internal fixation of ileum fractures is rarely indicated, but may be requested for cosmetic reasons. These fractures may be repaired by application of a bone plate, but reduction of the fracture may not be possible when the fragment is severely displaced.

**Humerus**

Non-articular, minimally displaced fractures of the humerus are best treated by stall confinement. In cattle, open reduction and internal fixation of the humerus with bone plates often causes permanent radial nerve paralysis. Use of an intramedullary interlocking nail may allow rigid fixation with minimal risk of radial nerve injury. The prognosis for healing the fracture with stall confinement is good, but the prognosis for return to normal productivity is guarded. Severely displaced or articular fracture of the humerus requires attempted internal fixation, but the prognosis is poor for return to normal productive use.

**Radius and ulna**

Closed fractures of the distal physis of the radius may be treated by a full limb cast and has a good prognosis for success. Fracture of the mid-radius and ulna requires use of a Thomas splint-cast, transfixation pin-cast, or bone plate. The prognosis for healing is good, but significant contralateral limb injury may occur in animals treated by Thomas splint-cast. Transfixation pinning and casting and bone plating have good to excellent prognoses with minimal risk of permanent injury to the contralateral limb. Where applicable and economical, I prefer to treat fractures of the radius and ulna using transfixation pinning and casting.

**Femur**

Femur fractures most often occur in calves during forced extraction for dystocia. Femur fractures are occasionally found in adult cattle after falling during mounting or on slippery flooring. The femur is generally difficult to radiograph in adult cattle. Most femoral fractures are readily diagnosed by physical examination. Femur fractures in mature cattle have a grave prognosis for success because of their body weight and an inability to reduce the fracture. Therefore, euthanasia is elected. However, some selected femur fractures may respond to stall rest for 8 to 10 weeks. Contracture and swelling of the heavy muscles of these animals serve to reasonably splint the injured bones.

In calves, stack pinning of the femur has a good prognosis for success. Open reduction of the fracture is performed, and 2 to 5 intramedullary pins are placed into the femur. If large cortical defects are present, then an external skeletal fixator may be applied in addition to the intramedullary pins. These fractures are usually healed by 6 weeks after surgery. Sepsis is the most common reason for failure of fracture healing.

**Tibia**

Although fracture of the tibia has been seen as a result of forced extraction during dystocia, tibia fractures are usually caused by trauma. Fracture of the distal physis of the tibia may be treated with a full limb cast, but these fractures are common. Fracture of the middle portion of the tibia may be treated by Thomas splint-cast, transfixation pinning and casting, or use of a bone plate. Thomas splint-casts have a good prognosis for bone healing, but have a high rate of injury to the contralateral limb. Transfixation pin-casts and bone plates have a good to excellent prognosis for healing, and minimal problems with contralateral limb injury.

**Metacarpus and metatarsus III/IV**

Fractures involving the metacarpus (MC) or metatarsus (MT) III/IV are the most common fractures to occur in food animals. These injuries often occur as a result of forced extraction during dystocia. Closed fracture of the distal physis of the MC or MT may be treated using a half limb cast. Closed fracture of the middle portion of the MC or MT may be treated with a full limb cast. Open fractures in mature cattle may be treated by thoroughly debriding, cleaning, and flushing the wound, applying a full limb cast, and administering antibiotics for 10 to 14 days. In valuable cattle and young calves, open fractures are best treated by use of an external skeletal fixator and daily wound care until the wound is healed. Bone sequestra are often associated with open fractures of the MC and MT. Bone healing may not occur until sequestra have been removed. If prolonged sepsis has been present, cancellous bone grafts may be required to facilitate bone union. The optimal site for
harvesting cancellous bone grafts are the wing of the ileum and the proximal tibia. Implantation of antibiotic impregnated bone cement beads into a septic wound will provide prolonged local release of antibiotics and may accelerate resolution of osteomyelitis.

**Phalanges**
Closed fractures of the phalanges may be treated by application of a 2.5 to 3.5 cm height block to the sole of the healthy digit. Confinement to a stall or small pen is recommended for 6 to 8 weeks.

**References**
References are available upon request.
Urolithiasis in Cattle
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Etiology
Urinary calculi may occur in both sexes but is far more common in males. The composition of the calculi is more variable in small ruminants than cattle, and the anatomy of the goat urethra makes clinical management more frustrating. Feedlot steers, show steers, and animals that are kept primarily as pets are often castrated at an early age. Castration before six to nine months of age does not allow the urethra to develop to its full diameter. Therefore, these animals are at an increased risk for developing urolithiasis. Unlike calculi formation in animals that are kept on range pasture, calculi that develop in steers and small ruminants are usually multiple and may be present at more than one location along the urinary tract. The mineral composition of the calculi is dependent on both geographic region and diet. The most common compositions of calculi are calcium apatite, struvite, and phosphatic. The most common sites for urethral obstruction are the sigmoid flexure and the vermiform appendage at the distal tip of the urethra in small ruminants. The diet should be adjusted to increase fiber and water intake and to acidify the urine (ammonium chloride at 300 mg/kg orally). Much of this presentation will focus on urolithiasis in small ruminants.

Diagnosis
The early diagnosis of urolithiasis is important in determining treatment options and prognosis. These animals will often display a stretched out stance and may flag the tail while making repeated attempts to urinate. These signs are often mistaken by the owner as signs of constipation. Other signs of urolithiasis may include abdominal discomfort, dribbling urine, lethargy, depression, anorexia, abdominal distention, preputial swelling, and gritty precipitates on the preputial hairs. A chemistry profile may reveal an increase in BUN and creatinine, normokalemia or hyperkalemia, hyponatremia, hypochloremia, increased CPK and AST, and possibly academia. A complete blood count may show a leukocytosis with a left shift. Ultrasound may show a distended bladder and/or urethra to the level of the calculus.

Medical management
Medical management includes fluid support with correction of any alterations in electrolytes, the use of anti-inflammatory drugs (flunixin meglumine at 1 mg/lb IV), and antibiotics for cystitis. Sedation of animals that present for obstructive urolithiasis may be necessary to facilitate physical examination and extension of the penis. Acepromazine hydrochloride may be given at 0.05 to 0.1 mg/kg intravenously or intramuscularly with a slaughter withdrawal of 7 days. Diazepam may also be given at a sedative dose of 0.1 mg/kg intravenously. There is no data available for meat withdrawal for diazepam but a 30 day meat withdrawal is considered adequate. A lumbosacral epidural with 2% lidocaine at a dose of 1mL per 10-20 pounds of body weight (do not exceed 15 mL total volume) may also be used to help extend the penis. In small ruminants, once the penis has been extended simple excision of the vermiform appendage may provide immediate relief from urinary obstruction. If an obstruction existed at the vermiform appendage, urine will immediately begin to flow from the urethral opening. Urethral patency has been reported to be restored in 37.5% to 66% of cases using this method. However, rarely does a single calculus cause an obstruction in small ruminants. Therefore, obstruction at this site or at another location along the urinary tract is likely. Catheterization in ruminants is very difficult due to the presence of the urethral diverticulum, and surgery is usually the best therapeutic option. Another option in certain cases is to use infuse Walpole’s solution (pH 4.5) into the bladder to help break down uroliths and crystals. This procedure should be performed under general anesthesia and utilizes ultrasound-guided transabdominal cystocentesis.

An 18 gauge, 4 inch needle is used to remove urine from the bladder. The bladder is then lavaged with 30-60 mL of Walpole’s solution and then removed. An additional 30-50 mL of Walpole’s solution is infused into the bladder in similar manner and left in bladder. In some cases urine flow resumes in 24-36 hours with normal voiding occurring in 3-5 days. Some animals may require a second cystocentesis in 2-3 days.

Surgical management
Several surgical options exist for obstructive urolithiasis in ruminants. The options include cystotomy, tube cystotomy, bladder marsupialization, perineal urethrostomy, penile amputation, and urethotomy. The most common procedures performed in small ruminants are the perineal urethrostomy, cystotomy, tube cystotomy, and bladder marsupialization. Penile amputation and ischial urethrostomy are most commonly performed in bulls. All of which will be discussed in further detail.

Cystotomy
Cystotomy and tube cystotomy offer the longest survival and return to breeding function. However, the cost of cystotomy may limit its use to pets and breeding animals. The animal is anesthetized and placed in dorsal recumbency. The skin is clipped and aseptically...
prepared. A right paramedian incision is made that is 2 to 3 cm off midline and extends cranially approximately 6 cm from the teats. The urinary bladder should then be identified and stay sutures placed at either end of the cystotomy site for greater stabilization of the bladder. The bladder is then opened and the bladder emptied and lavaged to remove all calculi. Normograde and or retrograde urethral flushing with an isotonic solution can be attempted. Once the urethra is cleaned of all visible stones, the cystotomy and abdominal incision are closed. However, if the urethra can not be cleared with 3 to 4 attempts of urethral flushing, then a tube cystotomy should be performed.

**Tube cystotomy**

Placement of a Foley catheter into the bladder and exiting through the ventral abdomen allows for continual drainage of urine. By routing urine flow through the catheter, the urethra is allowed to rest in order to decrease inflammation and promote healing. A small skin incision is made lateral to the paramedian incision and inserts the catheter subcutaneously, where it enters the abdomen and then the bladder. A purse-string suture is placed in the bladder wall to position the Foley. A small stab incision is made in the middle of the purse-string and the balloon end of the Foley catheter is placed into the bladder, after which the purse-string suture is tightened. After inflating the Foley catheter with saline, the bladder is tacked to the body wall with minimal tension. A one-way valve can be made from a finger of a latex glove and placed over the end of the catheter to create a type of Heimlich valve which helps decrease the incidence of ascending infections. The celiotomy site should be closed in three layers with an absorbable suture, and the subcutaneous tissues and skin closed in routine fashion. Sutures can be removed in 10 to 14 days. Clamping the catheter should begin on the fourth day after surgery to allow for normal urination. This should be done in a dry stall and with increasing duration until a full-stream urination is achieved. Normal urination should occur for 1 to 2 days before the catheter is deflated and removed. The Foley catheter should not be removed before day 7 after surgery to reduce the chances of urine leaking from the bladder. This bladder defect is allowed to heal spontaneously.

**Perineal urethrostomy**

Perineal urethrostomies have been performed in many sheep and goats and in young or lightweight cattle, but surgical failure, poor long-term survival rates due to strictures, and decreased reproductive function limit this to a salvage only procedure. The animal may be sedated heavily, given epidural anesthesia, or placed under general anesthesia. The perineal area is scrubbed and aseptically prepared. A skin incision is then made on the midline between the scrotum and the anus, and the retractor penis muscles and the penis are then identified. The penis is then exteriorized and rotated so that the dorsal blood supply can be ligated. As much of the penis as possible should be freed from the surrounding tissue in order to place the urethra in close proximity to the skin. The urethra is incised, and the urethral mucosa and tunica albuginea are sutured to the skin with as little tension as possible. The urethra is then sutured with a non-absorbable, monofilament suture in a simple interrupted pattern. The skin may then be closed in two layers with a non-absorbable, monofilament suture in a simple interrupted pattern. A Foley catheter can be placed into the urinary bladder for 3 to 4 days, and the animal placed on systemic antibiotics (procaine penicillin G 22,000 IU/kg IM BID) before surgery and for 3 to 5 days post-operatively. Sutures can be removed in 10 to 14 days. These animals can no longer be used for breeding. If strictures develop after surgery, bladder marsupialization may be performed. Prognosis for long-term survival after urethrostomy is guarded to poor because of stricture formation.

**Penile amputation**

Amputation of the penis may be indicated following rupture of the urethra in steers, bulls, rams, bucks, and wethers. Due to urine contamination of the peripenile elastic tissue at the site of the rupture, penile amputation may allow these animals to be salvaged for harvest after several weeks of healing. With the animal restrained in a squeeze chute, an epidural should be administered and the perineum should be prepared for aseptic surgery. The skin incision should allow for the penile stump to be directed caudoventrally to that urine flow will be directed at an angle between the hocks and tail. At the beginning of the anterioventral curvature of the perineum, at 12 cm skin incision should be made ventrally on the midline. The incision is then deepened through the subcutaneous and dense connective tissue between the semimebranous muscles to expose the paired retractor penis muscles. Continue dissecting deep between the retractor penis muscles to locate the penis. Grasp the penis firmly and apply traction caudally and dorsally to bluntly dissect the penis from the surrounding tissue. Dissection may be necessary unless advanced necrosis is present. Once the penis is exteriorized, the retractor penis muscles should be ligated and transected as far proximally as possible. If possible, the dorsal vessels may be dissected free from the penis without transection to preserve the nutrient blood supply to the distal portion of the penis and prevent sloughing of the penis (when minimal necrosis is present). The penis should then be transected with a scalpel 5 cm distal to the dorsal apex of the skin incision. The urethra should then be generously spatulated. It is not necessary to suture the cut end of the CCP in steers. However, there may be hemorrhage from this cavernous tissue in bulls when erection is stimulated. Wedge excision of the end of the stump with suture closure will minimize hemorrhage in bulls. Suture the penile stump to the skin with nonabsorbable, monofilament suture. The suture should be placed through the skin and body of the penis and exit through the skin on the opposite side of the incision. The second limb of the suture should then be placed through the skin, under the penis and exit the skin on the
original side of the incision and tie. This suture will prevent the penile stump from retracting into the incision. Using #2-0 chromic gut, closely spaced simple continuous sutures should be placed around the incision in the urethral mucosa to reduce hemorrhage from the CSP during urination. Hemorrhage from the CSP may still be a problem in bulls and large steers during urination. After suturing, a 15 cm length of 1 cm diameter latex tubing should be placed inside the urethra and fixed into place with a single suture through the tubing and penile stump. This tubing serves as a stent to compress the CSP and reduce hemorrhage in the early postoperative period. The tubing should be removed in 5 days. Systemic antibiotics should be administered for 5 days postoperatively, and the patient monitored for hemorrhage from the penile stump and for the ability of the animal to urinate. Sutures may be removed in 10 days. Stenosis of the urethral opening is one potential complication.

**Ischial uethrostomy**
The urethral diverticulum located on the dorsum of the urethra just inside the ischial arch makes bladder catheterization extremely difficult in ruminants. Ischial urethrostomy is used primarily to bypass the diverticulum and allow introduction of a catheter into the urinary bladder to provide urine egress. This may work as a salvage procedure for steers to reach acceptable slaughter conditions. This procedure may also be used to divert urine from the distal urethra when attempting surgical repair of urethral fistulae or urethral tears in bulls. In addition, this procedure may also be used in cases with ruptured bladders. Because the rupture typically occurs on the dorsum of the fundus, this indwelling urinary catheter provides urine drainage which prevents bladder distention. With the animal restrained in a squeeze chute, an epidural should be administered and the perineum should be prepared for aseptic surgery. A 10 cm vertical incision should then be made on the midline of the perineum beginning 5 cm below the anus. The incision should be deepened through the dense fascial place beneath the subcutaneous tissue to expose the paired retractor penis muscles. Next, bluntly dissect between the muscles and identify the bulbospongious muscle. The urethral groove should then be palpated immediately deep to the bulbospongious muscle. The incision should then be made along the median raphe of the muscle through the CSP and into the urethra which is easily identified by its smooth mucosal surface. There may be quite a bit of hemorrhage from the CSP. A pair of hemostats may then be inserted into the urethra in both directions in preparation for inserting the urinary catheter. A 10 French male dog catheter with sterile lubricant applied should be introduced into a Foley catheter to act as a stylet for insertion of the catheter into the urethra. Select a Foley with a 30mL cuff and of the largest diameter that will pass into the urethra, usually a 20 to 28 French in adult bulls. The lubricated catheter should then be inserted into the urinary bladder and the cuff inflated with sterile water. Be careful not to overinflate the cuff such that pressure necrosis of the bladder may occur. Place a one way valve on the end of the catheter to prevent aspiration of air into the bladder.

**Laser lithotripsy**
Laser lithotripsy has been successfully used in establishing urethral patency in a steer, goats and pot-bellied pigs. The procedure consists of passing an endoscope and laser fiber retrograde in standing bulls with a pudendal nerve block or in recumbent animals under general anesthesia. The endoscope may also be passed through an ischial urethrotomy site distally to the level of the calculus. Once the laser (holmium:yttrium-aluminum-garnet or Ho:YAG) reaches the calculus, it is then centered on the calculus and fired in a pulsatile manner with urethral flushing in between firing until the calculus fractures into fragments small enough to dislodge with hydropulsion or retrieve with a wire basket catheter. It is reported that previous chemolytic treatment in animals with surgical urinary diversion results in uroliths with uneven surfaces that fracture readily.

References available upon request.