Common Surgical Procedures in Camelids

David E Anderson, *DVM, MS, Diplomate ACVS*
Associate Professor, Food Animal Medicine and Surgery, College of Veterinary Medicine, The Ohio State University, 601 Vernon L Tharp Street, Columbus, OH 43210

Introduction

Veterinarians are commonly asked to perform surgery on llamas and alpacas. Several common surgical procedures are described including castration, gastrointestinal surgery, cesarean section, angular limb deformity and tooth-root abscess treatment.

Castration

Castration of llamas and alpacas may be chosen to allow commingling of pet or fiber producing males and females, to restrict the available genetic pool, to lessen aggressive behavior, and to create gelding males to be sold as pets or show animals. Timing of castration is controversial in llamas and alpacas. Barrington *et al*[3] cautioned that abnormalities of conformation have been observed in llamas castrated at a young age (e.g. < one year old). Llamas continue to grow until long bone growth reaches a plateau at approximately 18 to 24 months old.[26] Male hormones influence physeal closure, and early castration may alter this influence. Thus, early castration may cause a prolonged period of long bone growth and result in a "post-legged" conformation (joint hyperextension) which may predispose the llama to early onset osteoarthritis or patellar luxation. Thus, some authors advocate delay of castration until the male is 18 to 24 months old.[9]

Most castration methods that have been used in livestock, horses or pet animals may be used in llamas and alpacas. However, two methods have become standards of practice: scrotal castration[2,3] and pre-scrotal castration.[2,9,22]

Pre-operative preparation: Tetanus-toxoid vaccination and procaine penicillin G (10,000 U/lb; 22,000 U/kg) are administered to each animal before surgery is done. All food, but not water, should be withheld for 12 hours prior to castration if heavy sedation or general anesthesia will be used. Castration may be performed after sedation and local anesthesia or after induction of general anesthesia (Table 1).

Scrotal castration can be done with the animal standing or recumbent. For standing castration, the camelid is sedated (e.g. xylazine 0.2 mg/kg body weight, IM and butorphanol 0.1 mg/kg, IM) and local anesthesia is infiltrated along the median raphe and spermatic cords (2 ml of 2% lidocaine HCl each site). For general anesthesia, xylazine (0.3 mg/kg, IM), butorphanol (0.03 mg/kg, IM) and ketamine (3 mg/kg, IM) may be used. The scrotum is prepared for aseptic surgery using an

Table 1. Drugs used to provide anesthesia or analgesia in camelids.

Use	Drug	Dose	Route
Sedation	Xylazine HCl	0.1 to 0.3 mg/kg	IV, IM, SC
	Butorphanol tartrate	0.03 to 0.1 mg/kg	IV, IM, SC
	Medetomidine	10 to 30 ug/kg	IM
General Anesthesia	Butorphanol +	0.03 mg/kg	IM
	Xylazine +	0.3 mg/kg	IM
	Ketamine	3 mg/kg	IM
	Tiletamine/zolazepam	4.7 to 6.0 mg/kg	IM
	Halothane	1 to 5%	OTT or
	Isoflurane	1 to 5 %	NTT
Reversal Agents	Yohimbine	0.125 mg/kg	IV, IM
	Tolazoline[†]	1 to 2 mg/kg	IV, IM
	Atipamezole	0.125 mg/kg	IV

IV = intravenous; IM = intramuscular; OTT = orotracheal tube; NTT = nasotracheal tube
[†] Caution: acute death has been observed after rapid IV administration of tolazoline at high dosages.
Adapted from Sarno et al[25] and Waldridge et al[30]

antiseptic surgical scrub. A 2-cm incision is made on either side and parallel to the median raphe along the cranial and ventral most aspect of the scrotum. Each testicle is removed after transfixation ligation of the spermatic cord (e.g. No. 0 chromic gut, No. 2-0 polyglactin 910). Emasculation of the spermatic cord may be performed, but is not recommended because of its small size. Topical antiseptic and fly spray may be applied.

Pre-scrotal castration with skin closure should be done after induction of general anesthesia. Strict aseptic technique is critical to ensure that infection of the castration site does not develop. A 2 cm incision is made on ventral midline immediately cranial to the ventral base of the scrotum. Each testicle is removed through this incision and excised after transfixation ligation of the spermatic cord. After hemostasis has been achieved, the skin incision is closed using a subcuticular or subcutaneous suture pattern (e.g. No. 3-0 polyglecaprone; No. 2-0 polydioxonone).

Post-operative monitoring: Confinement is not required after castration, but daily examination of the surgical site is recommended during the healing of the wounds. The complication rate in camelids appears to be low (< 1%), but hematoma formation, hemorrhage, and infections have been observed.

Gastrointestinal Surgery

Historical Information

Although young camelids (< six months old) demonstrate clinical signs of acute abdominal pain (kicking at the abdomen, rolling, thrashing), these signs are less commonly observed in mature animals. Mature camelids demonstrate abdominal pain as restlessness, lying down and getting up frequently, vocalizing, grinding teeth, straining to urinate or defecate, flagging the tail, lying their head and neck flat against the ground or down across their back, and lying in an abnormal position.

Physical Examination

The clinician must differentiate abdominal diseases from those of neurologic or musculoskeletal origin. A thorough physical examination should be performed and include assessment of body stance, abdominal contour, rectal temperature, heart rate, respiratory rate and peripheral lymph node examination. The abdomen may be evaluated by transabdominal palpation, simultaneous auscultation / percussion / succussion, collection of fluid from the forestomach via orogastric intubation, and rectal palpation of animals of sufficient size to allow entry of the examiner's hand.[23] The animal's body condition should be evaluated for evidence of chronic weight loss or obesity.[15] Digital rectal should be done to determine if feces are present in the rectum. In females, urine collection may be done by catheterizing the bladder. A 5 French, 15-cm long polyurethane catheter is used and urine aspirated using a syringe. In males, routine catheterization of the bladder is not possible because of the presence of a urethral recess at the level of the ischial arch. Thus, urine must be obtained from males by a free-catch method.

Laboratory Data and Ancillary Diagnostic Tests

A CBC with differential, fibrinogen, serum electrolytes (e.g. Na, K, Cl, Ca, P), glucose, creatinine, BUN, SDH, GGT, cholesterol, albumin, total protein, and CPK should be done on all llamas and alpacas with clinical signs of abdominal pain. Ancillary tests commonly performed include first forestomach compartment fluid analysis, abdominal ultrasound, peritoneal fluid analysis, urinalysis, and fecal examination (e.g. fecal parasite egg count, occult blood analysis).[23] The urinary bladder in males cannot be routinely catheterized because of the presence of the urethral recess at the level of the ischial arch. However, urethral catheterization of females may be performed. A ventral urethral recess is present in female llamas and alpacas; the urethral opening is located along a transverse fold on the dorsal margin of this recess. Laboratory changes suggestive of surgical lesions of the gastrointestinal tract include hypochloremic hypokalemic metabolic alkalosis, elevated chloride concentration in the first forestomach compartment > 40 mEq/l, peritoneal fluid analysis indicating NCC > 5,000 cells/ul with > 80% polymorphonuclear cells (PMN) and protein > 3.0 g/dl.[23] Cebra *et al*[4] reported that indicators of poor prognosis among llamas and alpacas with surgical lesions include serum albumin < 3.5 g/dl, elevated serum creatinine and prolonged duration of clinical signs.

Indications for Surgery

Continuous and intractable pain is an indication for exploratory surgery. However, C3 ulcers in neonates, acute fatty liver disease and severe myopathy in adults can present with intense abdominal pain (Lapearle *et al* 1999). Persistent, low-grade discomfort despite supportive therapy is an indication for exploratory laparotomy. Abnormal rectal palpation or peritoneal fluid findings may be an indication for exploratory surgery. Failure to pass feces for > 24 hours is suggestive of intestinal obstruction. Failure to urinate for > six to eight hours is suggestive of urinary tract obstruction. Ultrasound identification of intestinal or urinary bladder distention is suggestive of intestinal or urethral obstruction, respectively. Exploratory surgery should not be used as a "last resort" to establish a diagnosis. Exploratory celiotomy can be done safely and efficiently when performed early in the progression of the disease. Laparotomy performed as an emergency or in a deteriorating patient is more likely to result in complications or death.

Anesthesia

Laparotomy may be performed with the patient sedated (e.g. butorphenol tartrate 0.1 mg/kg, IM), after local anesthesia, or after induction of general anesthesia (Table 1). The author prefers to perform exploratory laparotomies under general anesthesia because of optimal patient and surgeon comfort. Ideally, orotracheal or nasotracheal intubation should be performed (Reibold *et al* 1994). However, we have performed surgeries successfully using a right paralumbar fossae approach after sedation and local anesthesia.

Surgical Approach

Ventral midline or right flank celiotomy with the patient under general anesthesia are the approaches of choice for exploratory laparotomy. Paralumbar fossa laparotomy may be useful for access to the uterus, first forestomach compartment and spleen (left), third forestomach compartment and liver (right), small intestine and cecum and spiral colon exteriorization (right), or unilateral ovariectomy or nephrectomy. Ventral midline celiotomy is useful for access to the third forestomach compartment, liver, small intestine, large intestine, bladder or uterus.

Surgical Treatment

The most common reason for abdominal surgery in our practice is to perform Cesarian section either because of uterine torsion with poor cervical dilation or severe fetal malposition (see Cesarean section). Perforated C3 ulcer or intestinal obstruction are occasional causes of surgical gastrointestinal lesions. The most commonly reported causes of gastrointestinal lesions requiring surgery are summarized in Table 2. We have treated various intestinal diseases including: digesta impaction of the proximal loop of the spiral colon, ileocecocolic intussusception, enterolith obstruction of the spiral colon, extramural obstruction of the descending colon caused by an umbilical abscess,[27] hernia of the proximal loop of the spiral colon through a mesenteric rent, and post-operative obstructive adhesions with small intestinal strangulation. Urolithiasis has been reported to occur in male llamas and alpacas.[10,14,17,19] Impaction of the proximal loop of the spiral colon may be treated by instillation of saline into the mass, message of the impaction, and administration of IV fluids to maintain hydration, electrolyte and acid-base balance. Enteroliths may be removed via enterotomy. Compromised bowel (strangulation, intussusception) may be treated by resection and end-to-end anastomosis. Early diagnosis is critical to successful treatment of urolithiasis in llamas and alpacas. The author has successfully treated urolithiasis using tube cystotomy. Also, we have observed arterial thrombosis of the bladder in cases where treatment is delayed. Closure of the linea alba should be done using an appositional pattern. I prefer a cruciate suture pattern with No. 1 polydioxanone or polyglactin 910. The skin of the ventral midline in camelids is thin and pliable. Therefore, I routinely place a subcuticular suture pattern (No. 2-0 polyglactin 910 or polyglecaprone) and do not use skin sutures. The muscular wall of the paralumbar fossae is thin and contains minimal fascial support. Therefore, paralumbar fossa incisions must be closed with close attention to detail because the incisions are more prone to post-operative hernia formation compared with ventral midline incisions. I prefer to close all muscles (transversus m, internal abdominal oblique m, and external abdominal oblique m) in one layer so that each component provides support without sustaining maximal tension. A simple continuous suture pattern or interrupted tension-relieving sutures (e.g. cruciate suture pattern) using No. 1 PDS or No. 1 polyglactin 910 suture are appropriate choices.

Post-operative Management

Camelids appear to be fairly tolerant of intestinal surgery when performed early in the progression of the disease, but ileus and adhesions are prominent concerns. Antibiotics (e.g. procaine penicillin G 10,000 U/lb [22,000 U/kg] IM, q12hr x five days and gentamicin 2.27 mg/lb

Table 2. Common gastrointestinal lesions requiring surgery in llamas and alpacas.[4]

Diagnosis	Number affected	Number fatalities (%)	Survivors (%)
Proximal obstruction			
(small intestine, pylorus)	10	7 (70 %)	3 (30 %)
Ruptured viscus	4	4 (100 %)	0 (0 %)
Necrotizing enteritis	2	2 (100 %)	0 (0 %)
Distal obstruction			
(distal jejunum/ileum, large intestine)	13	3 (23 %)	10 (77 %)
Septic peritonitis	2	0 (0 %)	2 (100 %)

[5 mg/kg] IM, q24hr x three to five days), non-steroidal antiinflammatory drugs (e.g. flunixin meglumine, 0.45 mg/lb [1 mg/kg] IM, q12hr x two days), and ulcer prophylaxis (e.g. omiprazole, 0.9 mg/lb [2 mg/kg] po, q12-24h x five days) are routinely administered for three to five days after surgery. Incisional infection, hernia, peritonitis and intestinal adhesions are recognized complications of celiotomy. Cebra *et al*[4] reported that 12 out of 27 initial laparotomies and three out of four repeat laparotomies were successful; overall survival rate was 11 out of 27 animals. Reasons for death of the llama or alpaca included sepsis or peritonitis (n=5), respiratory distress (n=1), feed aspiration (n=1), and euthanasia during surgery because of grave prognosis based on surgeon's opinion (n=9).

Cesarean Section

Occurrence

Dystocia is relatively uncommon in llamas and alpacas, with fewer than 5% of birthings requiring assistance.[16] Problem birthings may be defined as failure of transition from stage I to stage II labor or when little to no progress is made for 30 minutes or more after the start of stage II labor. Most common causes of dystocia in llamas and alpacas are fetal malpositioning, uterine torsion and poor cervical dilation. Cesarean section was performed in three Dromedary camels because of dystocia caused by schistosoma reflexus, uterine torsion and fetal malposition. Cebra *et al*[7] reported that correction of uterine torsion by laparotomy was required in seven out of 20 llamas and alpacas. Of these seven animals, Cesarean section was performed in six.

Patient Assessment

Patient assessment is critical to successful alleviation of dystocia. Cardiovascular shock must be treated prior to correction of dystocia. Females having clinical signs of dehydration, hypotension, and shock should have an IV catheter placed and crystalloid fluids administered as needed. Non-steroidal anti-inflammatory drugs also may be used. Once supportive therapy has been initiated in the dam, the presentation, position, and posture of the fetus should be determined. If the size of the dam precludes evaluation of the uterus or fetus, then ultrasonography or radiography may be done to assess the fetus. However, immediate exploratory surgery and C-section may be a more prudent action.

Decision For Non-Surgical Treatment

Dystocia may be relieved without surgery if one of the following criteria can be achieved: 1) cervix is adequately dilated and the pelvis is of adequate size to extract the fetus; 2) pelvic dimension allows introduction of a hand into the uterus for fetal manipulation; 3) uterus has sufficient room to grasp and manipulate the fetus; or 4) sufficient room is available for fetotomy if the fetus is dead. If these criteria cannot be met, the decision to perform a C-section should be made without delay.

Decision For Surgical Treatment

In dystocia, if the uterus or fetus is not accessible or the cervix is closed, immediate C-section is indicated. Damage to the cervix or uterus is more likely when trying to force manipulation of the fetus despite inadequate space or cervical dilation. If size of the dam precludes transvaginal palpation, immediate C-section should be chosen. Delay in the decision to perform surgery may result in fetal or maternal death. In my experience, uterine laceration is more likely to occur in goats, llamas, and alpacas compared with sheep or cattle.

Cesarean Section (Hysterotomy)

Cesarean section is most easily performed via paralumbar fossa (left > right) or ventral midline laparotomy. The uterus should be exteriorized from the abdomen if possible. This is critical if extensive attempts at manual correction of dystocia have been tried or if the fetus is emphysematous. I routinely close the healthy uterus with No. 0 polydioxanone or polyglecaprone in a double-layer closure. De Wit[11] performed hysterotomies in 202 cows and compared hysterotomy closure with vicryl to that using plain cat-gut (n=99). There was no difference between these two suture materials, and no adhesions were detected in 45%; slight adhesions in 38%; and severe adhesions in 18% of cows. The uterus should be thoroughly lavaged clean of all blood clots prior to being replaced into the abdomen. I prefer to place an OB solution into the abdomen which is composed of 1 liter isotonic saline solution containing antibiotics (K-penicillin G 10,000 U/lb [22,000 U/kg] body weight, Na-ampicillin 9.1 mg/lb [20 mg/kg], or ceftiofur 0.45 mg/lb [1 mg/kg]), anti-inflammatory drugs (flunixin 0.45 mg/lb; 1 mg/kg), and heparin (9 to 18 units/lb; 20 to 40 units/kg) and is infused into the abdomen immediately prior to closure of the incision. Carboxymethyl cellulose (CMC 6.4 ml/lb or 14 ml/kg body weight, IP) has been evaluated and advocated for prophylaxis against post-operative adhesions. Post-operative adhesions after hysterotomy and CMC were similar to exploratory celiotomy without hysterotomy.

Uterine Torsion

Uterine torsion in llamas and alpacas usually occurs near term gestation. Camelids may show signs of abdominal pain or may simply lay down and appear to be depressed. Cebra *et al*[7] reported 20 cases of uterine torsion occuring in 11 llamas and three alpacas: 19 were clockwise in direction (left uterine horn rolling dorsal to the right uterine horn). Uterine torsion was corrected by rolling in eight dams, by celiotomy in seven dams, and by transvaginal manipulation in five dams. Surgery is indicated if correction is not achieved within two rolling attempts. Uterine torsion usually occurs at the termination of gestation, does not have a clear age or season predisposition, and can often be corrected without surgery. Clinical signs may include fever, tachycardia, tachypnea, anorexia, straining, and vaginal discharge. When the uterus cannot be corrected by rolling, when the cervix does not dilate sufficiently to deliver the fetus, or when fetal proportion or anomalies prevent delivery of the fetus, C-section is indicated. I prefer to perform left paralumbar fossa laparotomy regardless of the direction of the torsion.

Post-Operative Care

Antibiotics and non-steroidal anti-inflammatory drugs are administered for three days after surgery. Therapy may be prolonged for five to seven days if uterine laceration, abdominal contamination, or emphysematous fetus were present. Close attention should be paid to the cardiovascular stability of the dam, and rectal temperature should be determined daily for five days to monitor for the onset of peritonitis. Antimicrobial therapy should be directed against the most common bacteria resident in the normal post-partum uterus. I also administer flunixin meglumine (0.45 mg/lb; 1 mg/kg, IM or SC, q12hr) for 48 hours to limit adhesion formation.

Prognosis For Return To Breeding Soundness

Cesarean section is one of the oldest and most common surgical procedures requested for veterinarians to perform. There are three main goals of the Cesarean section: 1) survival of the dam, 2) survival of the fetus, and 3) maintenance of fertility. Success rates and complications associated with C-section in llamas and alpacas is limited. When C-section is performed early in dystocia and sterile technique is used, the re-breeding success rate is expected to be good. Complications reported to occur with uterine torsion in llamas and alpacas include retained placenta, uterine prolapse, and infertility (Cebra *et al*[7]). Eighteen of 20 (5 of 7 having C-section) animals successfully conceived a pregnancy after uterine torsion correction.

Angular Limb Deformity

Angular limb deformities (ALD) are common among llamas and alpacas. Veterinarians most commonly are asked to examine growing neonates for skeletal abnormalities, but these defects are not uncommon among adult llamas and alpacas. Owners may perceive that a mild angulation (< 5 degrees) in the forelimbs of adults is within the expected variation of normalcy. However, these angulations represent a skeletal defect and should not be encouraged as an acceptable phenotypic trait. ALD may be congenital or aquired. Congenital ALD most often is associated with prematurity. Premature neonates often have joint instability, presumably caused by immaturity of ligaments and surrounding muscle-tendon units. This results in altered weight bearing, which causes eccentric loading of the physes of the limb. Physes respond to biomechanical loading by changing the growth rates within the physis. Thus, ALD worsens if the limbs do not achieve normal angulation within a few weeks of birth. If joint laxity does not progress to normal within 10 to 14 days of birth or if the angle is severe enough to interfere with ambulation, splints should be applied to the forelimbs to aid in establishing normal conformation. Splints are usually maintained for seven to 10 days and removed. The cause of aquired ALD is probably multifactorial and may include hypovitaminosis D, micro- or macromineral imbalances (e.g. copper, calcium, phosphorus), trauma, genetics, or may be secondary to other musculoskeletal defects (e.g. injuries on one limb resulting in altered weight bearing on the remaining limbs). Van Saun *et al*[28] found that young llamas and alpacas with hypophosphatemia and hypovitaminosis D had a high prevelance of skeletal defects including angulation to the limbs resulting from altered long bone growth. Thus, selection of an appropriate treatment is dependent upon the probable cause of the ALD. If multiple neonates on a given farm suffer ALD, then complete nutrition evaluation must be performed and should include determination of serum vitamin D concentration. Hypovitaminosis D is not uncommon in North America and may cause altered physeal growth and deviation of the long bones. Clinical experience suggests that the distal physisi of the ulna and radius are particularly susceptible to the effects of hypovitaminosis D, also referred to as hypophosphatemic ricketts.

Clinical Evaluation

Llamas and alpacas have extensive hair growth on the limbs, often extending down to the foot. The presence of the hair may hide ALD from observation until later in life, when the first shearing is done or until the owner begins to prepare the animal for exhibition. ALD is described by the joint most affected by the angulation and by the direction to which the limb distal to the angulation is deviated (valgus = lateral deviation, varus = medial deviation). Evaluation of the affected limbs should be done either after shearing the limbs or by compressing the hair with bandage material wrapped firmly enough to see the contours of the limb. Paul-Murphy *et al*[21] found that the mean age of llamas examined for angular limb deformity was 6.2 months (range, 2.5 to

11 months). Males and females were equally represented and both forelimbs were affected in all animals.

Radiographic Evaluation

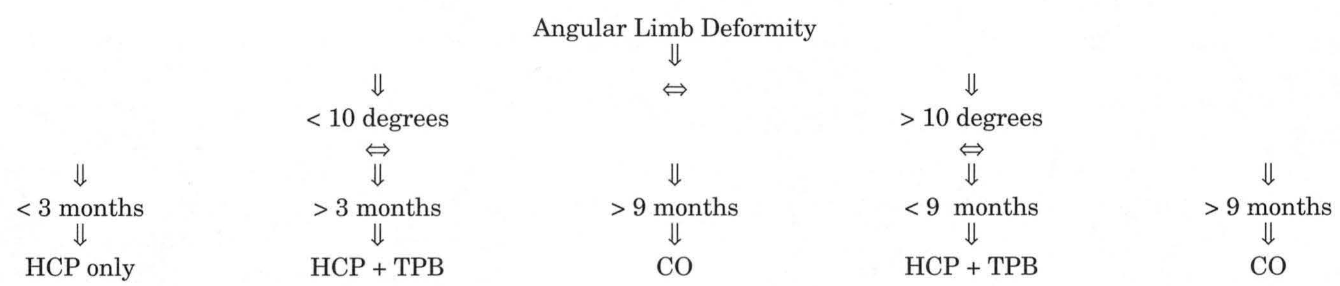
Radiographic examination of the limbs should be done to assess the severity of the angulation, determine if other skeletal defects are present such as absence or abnormal formation of bones within the affected joint, and to guide treatment option selection. Severity of angulation is determined by measuring the angle formed by the intersection of two lines drawn along the central longitudinal axis of the affected bones using the dorsopalmar (-plantar) or craniocaudal views. Paul-Murphy *et al*[21] reported a range of ALD of 6 to 25 degrees in 28 llamas with forelimb valgus. The point of intersection of lines drawn on the craniocaudal radiographic projection images was at the radial physis (33 out of 56), radial metaphysis (20 out of 56), or radial epiphysis (three out of 56). Of 56 limbs examined, 14 had ALD of 5 to 10 degrees, 30 had ALD of 11 to 15 degrees, six had ALD of 16 to 20 degrees, and six had ALD of 21 to 25 degrees. Also, 58% of affected radii had curvature of the radius present upon initial examination. Metaphyseal flaring at the distal radial physis and distal ulnar physis was observed in 95% of limbs examined. Of 41 limbs in which the third and fourth metacarpal bones were evaluated, 95% were found to have irregularities in the distal physis.

Treatment

This discussion will focus on carpal valgus originating at the level of the distal radius because this is the most common ALD requiring surgery and affecting llamas and alpacas. Congenital ALD is usually associated with laxity of the carpal joints, and is usually self-correcting or managed successfully without surgery. Selection of the best surgical option for treatment of ALD is based on severity and age of the affected llama or alpaca. Surgical options include: hemicircumferential periosteal elevation ("periosteal stripping", HCP), transphyseal bridging (TPB), and corrective osteotomy (CO). Figure 1 outlines a decision flow-chart the author uses for selection of the appropriate surgical method. Little data is available concerning rate of growth and age at closure of the distal physis of the radius in llamas and alpacas. However, phenotypic growth slows or plateaus at 18 months old. Llamas and alpacas are assumed to be similar to foals in that growth of the distal physis of the radius slows before nine months old. Therefore, neonates < three months old are assumed to have sufficient growth potential such that HCP can be effective.

HCP is performed on the distal lateral aspect of the radius when the animal is young and the ALD is mild (< 10 degrees). The author prefers to perform a partial (0.5 inch; 1-cm long) ulna ostectomy at the time of HCP to ensure that growth restriction by the ulna does not occur. A 2-inch (5-cm) long incision is begun immediately proximal to the distal physis of the ulna and continued proximally. The periosteum is elevated from the radius and ulna and a large bone rongeur is used to remove a 0.5 inch (1-cm) long segment of the ulna. The periosteal elevation is continued cranially and caudally, hemicircumferentially around the radius, and the periosteum is transected proximal and parallel to the distal physis of the radius. The periosteum is replaced against the radius and the skin is closed with an appositional suture pattern. A light pressure bandage is placed on the limb and maintained for seven to 14 days. Skin sutures are removed 14 to 21 days after surgery. The ALD should be re-evaluated 30 to 45 days after surgery to assess adequacy of correction.

TPB is done when the ALD is severe (>10 degrees) or the animal is older (e.g. closer to the time of limited growth potential in the distal physis of the radius). I usually chose to perform TB in neonates > three months old. I prefer to place needles at the intended location for screw placement and obtain a craniocaudal radiograph of the surgery site. One cortical bone screw (2.7 mm or



HCP = hemicircumferential periosteal elevation
TPB = transphyseal bridging
CO = corrective osteotomy

Figure 1. Treatment decision flow-chart for carpal valgus in llamas and alpacas.

3.5 mm diameter screws) is placed proximal and one distal to the medial aspect of the distal radial physis. Approximate location of the distal physis of the radius can be located by inserting an 18-gauge needle firmly into the bone at intervals of 1 to 2 mm, beginning immediately proximal to the metaphyseal prominence of the radius and continuing distally until soft bone is encountered and the needle can be seated for 0.5 cm. This procedure is more difficult to successfully perform in older neonates. Then, the screw hole is drilled, tapped and a screw inserted parallel to the physis until 0.5 cm of the screw is left protruding from the bone. Orthopedic wire (18 to 20-gauge) is placed around the two screws in a "figure 8" pattern and twisted until secure. Then, the screw is inserted until firmly against the bone. The skin is closed and a pressure bandage applied. The pressure bandage is removed in seven to 10 days, and skin sutures are removed after 14 to 21 days. The neonate must be examined daily to determine when the limbs are clinically straight, because overcorrection is possible if the screws are not removed quickly enough after the limb is straight. The critical time period is determined by the age and growth rate of the neonate and the severity of the defect.

Corrective osteotomy maybe performed after closure of the distal radial physis and when the severity of angulation precludes a good quality of life for the animal. Closing-wedge ostectomy is the procedure of choice, because this is more stable than opening-wedge osteotomy. An open-wedge osteotomy is made by performing an osteotomy at the distal aspect of the curvature and rotating the proximal fragment until the angle is corrected. Thus, a wedge-shaped gap remains on the concave side of the bone. A closing-wedge ostectomy is performed by removing a wedge-shaped piece of bone approximately the size of the angle formed by the curvature. For closing-wedge ostectomy, the bone wedge to be excised is estimated by drawing a line along the central axis from each end of the radius. The acute angle formed by the intersection of these lines is the degree of the arc of the wedge. An angle gauge is then applied such that the point of the wedge is on the concave cortex of the radius and the arc is on the convex aspect of the radius. Length of the arc is measured in centimeters, and this measurement used at surgery to estimate the size of the ostectomy. Squire *et al* (1991) reported bilateral wedge ostectomy for correction of bilateral carpal valgus exceeding 40 degrees in a 48-month-old llama. Each limb was operated three weeks apart and a closing-wedge ostectomy performed. The radius was stabilized using an orthopaedic bone plate (T-plate). The author successfully has performed several closing-wedge ostectomies in llamas and alapacas and used transfixation pin casting or external skeletal fixation to stabilize the affected bone.

Tooth Root Abscess

Significance and Etiology

Tooth root abscesses are relatively commonly diagnosed in llamas and alpacas in North America. Clinical examination of infected teeth suggests that tooth root abscesses are caused by periodontal disease. In most cases, the crown and pulp cavity are not disrupted. Rather, the periodontal membrane is disrupted by penetration of food particles. Although tooth root abscesses may be seen in llamas and alpacas of any age, Cebra *et al*[5] reported that the median age was five years. Also, the most commonly infected teeth are the molars. Thus, the onset of tooth root abscess occurs during or immediately following the period of eruption of the permanent molars. We have associated development of tooth root abscess with the feeding of coarse fiber (stemmy) hays. These observations have led us to form a hypothesis that tooth root abscesses occur as a result of grinding excessively coarse foodstuffs during the period of periodontal exposure while the deciduous teeth are lost and permanent teeth are erupting. Tooth root abscesses involving the canine teeth are unique in that trimming of the crown of the tooth is a routine annual procedure, especially in males.[18] Exposure of the pulp cavity or splitting of the tooth during trimming may result in bacterial infection of the tooth root or dental alveolus.

Clinical Signs

Llamas and alpacas with tooth root abscess are most commonly presented for examination because the owner noticed a firm swelling on the face with or without purulent drainage. Other clinical signs may include hypersalivation, altered mastication, weight loss and apparent pain.[5]

Diagnosis

Physical examination reveals a firm swelling on the mandible. This swelling may be a large mass with edema, scar tissue, a soft fluctuant center, and bone proliferation, or may be small and confined entirely to the intermandibular space. Most often, no external drainage is noted. The swelling most often is located along the horizontal ramus of the mandible, but occasionally a rostral lesion is found near the canine teeth. Radiographic examination is the diagnostic test of choice. Radiographic images obtained should include lateral, dorsoventral and oblique images. Radiolucency is observed surrounding the affected tooth, and bone proliferation may be noted if a cloaca has developed from the abscess. The dorsoventral projection is needed because abscesses may be confined to the medial aspect of the tooth root and may not be observed on lateral or oblique images. Intraoral images can be obtained with the animal sedated or anesthetized, and these images provide the highest detail for accurate diagnosis. Involvement of multiple teeth is not uncommon.

Treatment and Prognosis

Treatment options for tooth root abscess include tooth extraction, tooth splitting, tooth root resection, root canal, bone debridement with long-term (e.g. four to six weeks) antibiotic administration, or long-term antibiotic administration, alone. Removal of a premolar or molar tooth should be done with the patient under general anesthesia. A lateral approach to the mandible is made by a semicurved incision with a dorsal base. The periosteum is reflected dorsally and a compressed air-driven burr used to remove the lateral alveolar plate of the mandible. The tooth is removed and the alveolus debrided. Tooth repulsion by impact, such as that used in horses, is not recommended for use in llamas because the thin mandible is prone to fracture. The author caused fracture of two out of 20 mandibles using this technique. After changing technique to lateral alveolar plate resection, no mandible fractures have occurred. Cebra *et al*[5] reported success rates after tooth removal of 100% (four of four) and after medical treatment (some with and some without debridement) of 62% (eight of 13). Of the five llamas having failure of medical treatment, three were subsequently cured by surgical treatment of the affected tooth, two had continued medical or conservative treatment, and one died from juvenile immunodeficiency syndrome. In our experience, medical treatment of tooth root abscesses results in initial improvement that may continue for two to 12 months. However, recurrance of the abscess eventually is found in most animals receiving only medical treatment. Surgical treatment at the time of recurrance is curative.

References

1. Anderson DE, Gaughan EM, Baird AN, Lin HC, Pugh DG: Laparoscopic surgical approach and anatomy of the abdomen in llamas. *J Am Vet Med Assoc* 208(1):111-116, 1996.
2. Baird AN, Pugh DG, Wenzel JGW, Lin HC: Comparison of two castration techniques for castration of llamas. *J Am Vet Med Assoc* 208 (2): 261-262, 1996.
3. Barrington GM, Meyer TF, Parish SM: Standing castration of the llama using butorphenol tartrate and local anesthesia. *Equine Pract* 15(5):35-39, 1993.
4. Cebra CK, Cebra ML, Garry FB, *et al*: Acute gastrointestinal disease in 27 new world camelids: clinical and surgical findings. *Vet Surg* 27:112-121, 1998.
5. Cebra ML, Cebra CK, Garry FB: Tooth root abscesses in new world camelids: 27 cases (1972-1994). *J Am Vet Med Assoc* 209:819-822, 1996.
6. Cebra CK, Cebra ML, Garry FB, Belknap EB: Forestomach acidosis in six new world camelids. *J Am Vet Med Assoc* 208(6):901-904, 1996.
7. Cebra CK, Cebra ML, Garry FB, Johnson LW: Surgical and non-surgical correction of uterine torsion in new world camelids: 20 cases (1990-1996). *J Am Vet Med Assoc* 211(5):600-602, 1997.
8. Costarella CE, Anderson DE: Ileocecocolic intussusception in a one-month-old llama. *J Am Vet Med Assoc* 214(11):1672-1673, 1999.
9. Dargatz DA, Johnson LW: Castrating the llama: a step-by-step guide. *Vet Med* 625-627, 1987.
10. Dart AJ, Dart CM, Hodgson DR: Surgical management of a ruptured bladder secondary to a urethral obstruction in an alpaca. *Australian Vet J* 75(11):793-795, 1997.
11. De Wit F, Raymakers J Westerbeek, *et al*: Een onderzoek naar vergroeiingen van de uterus na het hechten van de uterus met catgut of vicryl bij de sectio caesarea van het rund. *Tijdschr Diergeneeskd* 118:478-479, 1993.
12. Elias E: Left ventrolateral cesarean section in three Dromedary camels (*Camelus dromedarius*). *Vet Surg* 20:323-325, 1991.
13. Fowler ME: Angular limb deformities in young llamas. *J Am Vet Med Assoc* 181:1338-1341, 1982.
14. Gerros TC: Recognizing and treating urolithiasis in llamas. *Vet Med* 583-590, 1998.
15. Hilton CD, Pugh DG, Wright JC, Waldridge BM, Heath AM: How to determine and when to use body weight estimates and condition scores in llamas. *Vet Med* 1015-1018, 1998.
16. Johnson LW: Parturition in the llama, in: Youngquist (ed): *Current Therapy in Large Animal Theriogenology*. Philadelphia, WB Saunders, 1997, pp 813-817.
17. Kingston JK, Staempfli HR: Silica urolithiasis in a male llama. *Can Vet J* 36:767-768, 1995.
18. Kock MD: Canine tooth extraction and pulpotomy in the adult male llama. *J Am Vet Med Assoc* 185(11):1304-1306, 1984.
19. McLaughlin BG, Evans NC: Urethral obstruction in a male llama. *J Am Vet Med Assoc* 195(11):1601-1602, 1989.
20. Moll HD, Wolfe DF, Schumacher J, *et al*: Evaluation of sodium carboxymethylcellulose for prevention of adhesions after uterine trauma in ewes. *Am J Vet Res* 53:1454-1456, 1992.
21. Paul-Murphy JR, Morgan JP, Snyder JR, *et al*: Radiographic findings in young llamas with forelimb valgus deformities: 28 cases (1980-1988). *J Am Vet Med Assoc* 198(12):2107-2111, 1991.
22. Pugh DG, Baird AN, Wolfe DF, Wenzel JGW, Lin HC: A prescrotal castration technique for llamas. *Equine Pract* 16(4):26-28, 1994.
23. Pugh DG, Navarre CB, Ruffin DC, Belknap EB: A review of diagnostic procedures in llamas and alpacas. *Vet Med* 654-659, 1999.
24. Reibold TW. Engel HN, Grubb TL, Adams JG, Huber MJ, Schmotzer WB: Orotracheal and nasotracheal intubation in llamas. *J Am Vet Med Assoc* 204(5):779-783, 1994.
25. Sarno RJ, Hunter RL, Franklin WL: Immobilization of guanacos by use of tiletamine/zolazepam. *J Am Vet Med Assoc* 208:408-409, 1996.
26. Smith BB, Timm KI, Reed PJ: Morphometric evaluation of growth in llamas (*Lama glama*) from birth to maturity. *J Am Vet Med Assoc* 200(8):1095-1100, 1992.
27. St-Jean G, Anderson DE, Anderson NV, Hoskinson J: Abdominal pain associated with an umbilical abscess in a llama. *Cornell Vet* 83:77-81, 1993.
28. Van Saun RJ, Smith BB, Watrous BJ: Evaluation of vitamin D status of llamas and alpacas with hypophosphatemic ricketts. *J Am Vet Med Assoc* 209(6):1128-1133, 1996.
29. Yarborough TB, Snyder JR, Harmonn FA: Laparoscopic anatomy of the llama abdomen. *Vet Surg* 24:244-249, 1995.
30. Waldridge BM, Hui-Chu L, DeGraves FJ, *et al*: Sedative effects of medetomidine and its reversal in llamas. *J Am Vet Med Assoc* 211:1562-1565, 1997.
31. Wilson DG: Surgery of the genitalia of llamas, in Youngquist (ed): *Current Therapy in Large Animal Theriogenology*. Philadelphia, WB Saunders, 1997, pp 840-843.

The calves from hospital pen J-14 felt so much better after Banamine®, they couldn't wait for the morning feed run.

Banamine controls the fever and inflammation associated with bovine respiratory disease and helps restore appetite. In most cases, you'll see vast improvement in eating behavior within 12 hours of administration.

In fact, a recent Nebraska feedyard study shows Banamine-treated animals made 17 percent more trips to the bunk and spent 36 percent more time there than animals treated with an antibiotic alone.*

Animals feel better fast with Banamine. The sooner they feel better, the sooner they'll get back on feed. Treat with Banamine. You—and your producers—will like what you see at the bunk.

For more information, contact your Schering-Plough Animal Health sales representative or call our Technical Services Department at 1-800-211-3573.

Use judiciously when renal impairment or gastric ulceration is suspected. In cattle, rare instances of anaphylactic-like reactions, some of which have been fatal, have been reported, primarily following intravenous use. See accompanying Product Information summary on page 117 for important information.

BANAMINE®
(flunixin meglumine)

Jump Start Recovery. Restore Performance.

Schering-Plough Animal Health Corp.

Schering-Plough Animal Health
EXPERTISE...COMMITMENT...VALUE

*Study on file at Schering-Plough Animal Health Corp.